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Selected Irrigation Return Flow Quality Abstracts 1968-1969

Robert S. Kerr Water
Research Center

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Selected Irrigation Return Flow Quality Abstracts 1968–1969

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~~This first annual issue of SELECTED IRRIGATION RETURN FLOW QUALITY ABSTRACTS covers publications printed in 1968 and 1969. This report was submitted in fulfillment of Project Number 13030FVN, Contract 14-12-01, under the sponsorship of the Office of Research and Monitoring, Environmental Protection Agency.~~

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October 1972

SELECTED IRRIGATION RETURN FLOW QUALITY ABSTRACTS 1968-1969

First Annual Issue

by

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ABSTRACT

Research related to the quality of irrigation return flow is being conducted at numerous institutions throughout the western United States. Related work is also underway at other institutions in the United States, as well as other portions of the world. Approximately 100 sources of material have been searched for articles pertinent to the National Irrigation Return Flow Research and Development Program. These articles describe water quality problems resulting from irrigated agriculture, potential technological solutions for controlling return flows, recent research pertinent to return flow investigations, and literature associated with institutional constraints in irrigation return flow quality control.

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Key Words: Fertilizers, Irrigated Land, Irrigated Systems, Irrigation Water, Nitrates, Phosphates, Return Flow, Salinity, Water Pollution Effects, Water Pollution Sources, Water Quality Control

FOREWORD

The first annual issue of SELECTED IRRIGATION RETURN QUALITY ABSTRACTS has been compiled from approximately 100 sources of material covering calendar years 1968 and 1969. This compilation has attempted to include technological and institutional articles that would be pertinent to action programs regarding the control of water quality degradation resulting from irrigated agriculture.

The state-of-the-art report, "Characteristics and Pollution Problems of Irrigation Return Flow" prepared by the Utah State University Foundation (see abstract 68-69:05B-028 on page 129) contains a bibliography of articles pertinent to Irrigation Return Flow Quality Control. The references in this bibliography include articles and reports prior to 1968.

The first annual issue contains more than 400 abstracts of documents published during calendar years 1968 and 1969. The abstracts have been placed into sections according to the category and subgroup classifications used by the Water Resources Scientific Information Center (WRSIC) as published in the report, "Water Resources Thesaurus." The abstracts have been forwarded to WRSIC for inclusion in their bi-monthly publication, "Selected Water Resources Abstracts."

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SECTION I

WATER CYCLE - GENERAL (Group 02A)

68-69:02A-001
DRAINAGE DESIGN THEORY AND PRACTICE,
Nwa, E. U., and Twocock, J. G.
Ministry of Agriculture, Fisheries and Food, Cambridge, England. Field Drainage Experiment Unit.
Journal of Hydrology, Vol. 9, No. 3, p 259-276, November 1969. 10 fig, 2 tab, 15 ref.

Descriptors: *Drainage systems, *Soil water movement, *Groundwater movement, *Drainage engineering, Water management (Applied), Drainage practices, Evaluation, Design, On-site investigations, Mathematical studies, Model studies, Ditches, Drainage programs, Agricultural engineering.
Identifiers: Drainage design theory.

Several drainage equations were chosen to compare them with the performance of an existing drainage scheme. A review of the drainage theories chosen is reported. The auger-hole method was used to determine the average hydraulic conductivity used in the calculation, and the variable drainable porosity was determined using Taylor's method. The drain discharge and the shape of the water table were determined by means of a flowmeter, and lines of piezometers, respectively. Two rainfree periods were selected for the experiment. The water table profile tends to indicate an essentially flat water surface. All the equations tested, except Luthin's, gave an average calculated spacing which is larger than the actual spacing. It is concluded that the site could perform as well as it is doing now with a wider spacing. More research is recommended before one or two equations could be chosen to aid the design of drainage schemes.

68-69:02A-002
WATER DISTRIBUTION UNDER SPRINKLER IRRIGATION,
Pair, Claude H.
Agricultural Research Service, Kimberly, Idaho, Snake River Research Center.
Transactions of the American Society of Agricultural Engineers, Vol. 11, No. 5, p 648-651, September-October, 1968. 7 tab.

Descriptors: *Irrigation efficiency, *Irrigation systems, *Water distribution (Applied), *Sprinkler irrigation, Wind velocity, Rates of application, *Uniformity coefficient, Laterals, Infiltration, Idaho, Distribution systems.

Water distribution from a handmove sprinkler system was studied during a normal irrigation season in southern Idaho. Five types of sprinkler systems operating individually and three types of systems operating simultaneously had uniform sprinkler heads, nozzle sizes, sprinkler spacing on the lateral, nozzle pressure and wind conditions. Water distribution was compiled from spray catch cans. Comparison of water distribution from three types of sprinkler systems operating simultaneously showed that the straight-lateral, self-propelled sprinkler gave a higher coefficient of uniformity than the handmove or side move with trailer line systems. Multiple irrigations by handmove portable sprinkler laterals gave acceptable seasonal water distribution as measured by the Christiansen coefficient of uniformity, even though some individual irrigations yielded poor water distribution.

SECTION II

WATER CYCLE - EVAPORATION AND TRANSPIRATION (Group 02D)

68-69:02D-001
POTENTIAL EVAPORATION AS A MANIFESTATION OF REGIONAL EVAPORATION,
Morton, F. I.
Department of Energy, Mines, and Resources, Ottawa, Ontario, Canada, Hydrologic Sciences Division.
Water Resources Research, Vol. 5, No. 6, p 1244-1255, December 1969. 5 fig, 2 tab, 14 ref.

Descriptors: *Evaporation, *Mathematical models, Energy budget, Heat balance, Water balance, Mass transfer, Meteoric water, Meteorology, Microenvironment, Saturation, Solar radiation, Temperature, Vapor pressure, Water loss, Evaporators, Humidity, Evapotranspiration.
Identifiers: Potential evaporation.

The temperature and humidity of the lower atmosphere are treated as causes of evaporation from a small continuously moist area and as effects of evaporation from a large area with variable moisture supply. This leads to the formulation of a model in which the sum of the regional and potential evaporation is equal to the evaporation equivalent of the absorbed insolation. Such a formulation permits the regional evaporation, a product of climatic, soil moisture, and vegetation processes, to be estimated by its effects on climatologic or evaporimeter observations. Test data are derived from class A evaporation pan observations from the near-arid regions of the southwestern United States, and the near-humid regions of Ireland and from records of rainfall and runoff for Irish river catchments. Comparisons with the model predictions provide good evidence for the validity of the model and interesting insights into its hydrologic and climatologic implications.

68-69:02D-002
AN EMPIRICAL METHOD FOR ESTIMATING MONTHLY POTENTIAL EVAPOTRANSPIRATION IN NEVADA,
Behnke, Jerold J., and Maxey, George B.
Agricultural Research Service, Fresno, California.
Journal of Hydrology, Vol. 8, No. 4, p 418-430, August 1969. 4 fig, 3 tab, 11 ref.

Descriptors: *Evaporation, *Nevada, Arid lands, Lysimeters, Estimating, Evaporation pans, Climates, Topography, Weather, Solar radiation, Evapotranspiration.
Identifiers: Thornthwaite evapotranspiration.

Monthly potential evapotranspiration values were obtained for several stations throughout the State of Nevada using the Thornthwaite and Olivier equations. The Olivier equation correlated well with lysimeter and adjusted pan data as an estimate of ET. On an annual basis the Thornthwaite equation was approximately 50% too low. A technique was developed to estimate wet bulb depression from temperature data. This made it possible to solve the Olivier equation using only temperature data as input. Climatic conditions in Nevada were such that it was possible to apply the dry adiabatic lapse rate to a centrally located base station to obtain temperature values for other locations lacking climatic data. On a monthly basis, this 'modified' Olivier equation correlated satisfactorily with the original equation for Nevada locations ranging in elevation from 2171 to 5136 ft and in latitude from 36 deg to 41 deg N.

68-69:02D-003
EVAPORATION FROM DRYING SURFACES BY THE COMBINATION METHOD,
Fuchs, M., Tanner, C. B., Thurtell, G. W., and Black, T. A.
Wisconsin University, Madison, Department of Soil and Water Sciences.
Agronomy Journal, Vol. 61, No. 1, p 22-26, January-February, 1969. 3 fig, 1 tab, 22 ref.

Descriptors: *Evaporation, Soil temperature, Heat flow.
Identifiers: *Combination formula, *Aerodynamic transfer coefficient.

Preceding page blank

The combination formula which explicitly includes the surface temperature is used to predict the hourly evaporation from a drying bare soil. The formula is valid regardless of the water vapor saturation deficit at the surface, but the measurement of the surface temperature limits its application to surfaces having a well-defined boundary with the atmosphere. Agreement with hourly evaporation measured by lysimetry at the same site was only fair because of a thermal lag in the energy balance of the lysimeter, but very good (within 1%) for the average daily values where the effect of thermal lag is negligible. All combination formulas use an aerodynamic transfer coefficient, which must include adiabatic profile corrections unless sensible heat flux density is small relative to evaporation. Eddy correlation measurements of the sensible heat flux density into the air confirmed the transfer coefficient used. It is finally shown that the additional measurement of the water vapor pressure of the air can be used to relate the actual evaporation to a usefully defined potential evaporation.

68-69:02D-004
THE R INDEX FOR PLANT WATER REQUIREMENT,
Yao, A. Y. M.
Environmental Data Service, Silver Springs, Maryland.
Agricultural Meteorology, Vol. 6, p 259-275, 1969. 12 fig, 2 tab, 7 ref.

Descriptors: *Evapotranspiration, *Model study, Land use, Soil-water-plant relationships.
Identifiers: *R index, Beta distribution, Kolmogorov-Smirnov method.

The frequency distribution model of the monthly and the bi-weekly R index, the ratio of actual evapotranspiration to potential evapotranspiration, is discussed and compared with the Beta distribution. The goodness of fit of the Beta distribution to the R index frequency distribution was tested using the Kolmogorov-Smirnov method for 173 station-month and bi-weekly curves. For values of R<0.95, the Kolmogorov-Smirnov test specified no rejection, at the 15% level, of the hypothesis that the R index follows a Beta distribution. With R>0.95, 36 of the 173 R index curves failed the K-S tests. However, R>0.95 has only very limited value for most agricultural plants. The probability distribution of R can, therefore, be used as a tool to help solve the problems of agricultural land use capability, long term agricultural planning, irrigation project design, and agricultural drought.

68-69:02D-005
CONCEPTS OF SOIL MOISTURE AVAILABILITY AND THEIR EFFECT ON SOIL MOISTURE ESTIMATES FROM A METEOROLOGICAL BUDGET,
Baier, W.
Canada Department of Agriculture, Plant Research Institute, Ottawa, Ontario.
Agricultural Meteorology, Vol. 6, p 165-178, 1969. 3 tab, 5 fig, 13 ref.

Descriptors: *Soil moisture, *Evapotranspiration, *Moisture availability, *Meteorology, Meteorological data, Evaporation, Transpiration.
Identifiers: *Versatile soil moisture budget.

Soil moisture measurements by means of Colman electrical resistance blocks over 10 years were used to test the effect of various relationships between plant-available soil moisture (SM) and the ratio of actual (AE) to potential (PE) evapotranspiration on soil moisture estimates obtained by the Versatile Budget. Depending on the type of relationship used, correlation coefficients (ranging from 0.76 to 0.85) between 5-day means of SM observations and estimates differed significantly and mean errors varied from 3% to 39% of the observed seasonal means. Under the local experimental conditions, a linear relationship between SM and AE/PE gave estimates most closely related to the observations. The results suggest that when a realistic SM vs. AE/PE relationship is used in the Versatile Budget, a precision of the estimates comparable to the error involved in measuring soil moisture in the field by conventional methods can be achieved.

68-69:02D-006

EVAPORATION FROM A SIMULATED SOIL SHRINKAGE CRACK,

Adams, J. E., Ritchie, J. T., Burnett, E., and Fryrear, D. W.
Agricultural Research Service, Temple, Texas.
Soil Science Society of America Proceedings, Vol. 33, No. 4, p 609-613, July-August, 1969. 2 tab, 4 fig, 6 ref.

Descriptors: *Evaporation, *Evaporation control, *Mulching, Water conservation.
Identifiers: *Soil shrinkage crack.

A simulated soil shrinkage crack, 46 cm wide and 62 cm deep, was constructed in such a manner that depth could be varied by 15.2 cm increments and width could be adjusted between 10 and 70 mm by 20 mm intervals. The walls of the crack were lined with porous ceramic plates connected to a water supply maintained at -5 mb potential. The simulated crack was installed in the floor of a laboratory wind tunnel located in a controlled environment room maintained at 24.0 ± 1.5C air temperature and 43 ± 3% relative humidity. Evaporation from the simulated crack walls (ceramic plates) was determined for all combinations of four crack widths (10, 30, 50, and 70 mm), three crack depths (30, 45, and 60 cm) and five windspeeds (0, 2.2, 4.5, 6.7, and 8.9 m sec^{-1}). Total water loss (evaporation) from the walls of the simulated crack increased as any one or all of the three variables (windspeed, crack depth, or crack width) increased. These three variables accounted for 99.1% of the variability in total evaporation from the crack walls. Turbulent air movement within the simulated crack was the major factor affecting the evaporation. Both straw and gravel mulches reduced evaporation from the crack walls 85 to 90% with no wind and about 60% at 8.9 m sec^{-1} windspeed. The results suggest that evaporation from soil shrinkage cracks may be reduced by closer plant or row spacing or by surface residues such as trash and clod mulches.

68-69:02D-007

SOIL-WATER DIFFUSIVITY VALUES BASED UPON TIME DEPENDENT SOIL-WATER CONTENT DISTRIBUTIONS,

Cassel, D. K., Warrick, A. W., Nielsen, D. R., and Biggar, J. W.
California University, Davis, Department of Water Science and Engineering.
Soil Science Society of America Proceedings, Vol. 32, No. 6, p 774-777, December 1968 7 fig, 3 tab, 7 ref.

Descriptors: *Soil-water infiltration, *Diffusion
Identifiers: Bulk density.

A laboratory method based upon time dependent soil-water content distributions is presented for calculating isothermal soil-water diffusivity values for soils at 5 to 15 volume percent water. The redistribution of water within sealed soil columns was monitored by gamma-radiation attenuation at approximately 100 to 1,000 hour intervals over a period exceeding 3 months. Diffusivity values from numerical integration of the diffusion equation were obtained easily and compared favorably with those of previous investigators.

68-69:02D-008

PLANT GROWTH-EVAPOTRANSPIRATION RELATIONS FOR SEVERAL CROPS IN THE CENTRAL GREAT PLAINS,

Hanks, R. J., Gardner, H. R., and Florian, R. L.
Utah State University, Logan.
Agronomy Journal, Vol. 61, No. 1, p 30-34, January-February, 1969. 5 fig, 1 tab, 9 ref.

Descriptors: *Evapotranspiration, *Evaporation, *Lysimeters, *Transpiration, Wheat, Oats, Millet, Water conservation, Water utilization, Dry land farming.
Identifiers: Great Plains.

Lysimeters, which eliminated runoff and percolation below 90 cm, caused about 10 cm of additional water to be available for growth of grain sorghum in 1967. This additional water doubled yields, with an increase in evapotranspiration of only 50%. Evaporation from soil in the lysimeter was only 32% of the evapotranspiration, compared with 50% for the soil surrounding the lysimeter. Evaporation from the soil within a winter wheat crop during the actively growing period in the spring, was estimated to be 15 and 37% of evapotranspiration for 1966 and 1967 respectively.

Evaporation from the soil within the actively growing crop was estimated to be 34 and 20% of the evapotranspiration for oats and millet, respectively. Estimates of the amount of water evaporated from the soil within a crop allowed for estimation of transpiration from measurements of evapotranspiration. This data indicate that production and transpiration are directly related in this dryland area as de Wit (3) suggests.

68-69:02D-009
IN SITU MEASUREMENT OF SOIL AND PLANT LEAF WATER POTENTIAL,
Rawlins, S. L., Gardner, W. R., and Dalton, F. N.
U.S. Salinity Laboratory, Soil and Water Conservation Research Division, Agricultural Research Service, Riverside, California.
Soil Science Society of America Proceedings, Vol. 32, No. 4, p 468-470, July-August, 1968. 2 fig, 6 ref.

Descriptors: *Transpiration, *Tensiometers.
Identifiers: *Soil water potential, Thermocouple psychrometer.

For a pepper plant (Capsicum frutescens L.) growing in a greenhouse, soil water potential was measured with tensiometers and a thermocouple psychrometer, plant water potential was inferred from a calibrated beta gauge, and transpiration was measured by weighing the soil-plant system. Water moved through the transpiration stream in the direction of the gradient of the water potential. Regardless of the distribution of water in the soil, transpiration was unaffected by soil water content until it dropped to a value corresponding to -6 to -8 bars water potential. Below this water content, transpiration decreased linearly with soil water content to a soil water potential of -37 bars. At this time the plant water potential was below -50 bars and the transpiration rate was near zero. After irrigation the plant regained full turgor.

68-69:02D-010
A PHYSICAL ANALYSIS OF DIURNAL TEMPERATURE REGIMES IN CLEAR AND TURBID WATER LAYERS: A PROBLEM IN RICE CULTURE,
Rose, C. W., and Chapman, A. L.
CSIRO, Division of Land Research, Canberra, A.C.T., Australia.
Agricultural Meteorology, Vol. 5, p 391-409, 1968. 9 fig, 2 tab, 18 ref.

Descriptors: *Rice, *Turbidity, *Water temperature, *Solar radiation, Radiation, Diurnal distribution, Irrigation, Thermoperiodism, Evaporation control.
Identifiers: Thermal transport.

Previous work has shown that water temperature is an important factor in the establishment of a rice crop by broadcasting pregerminated seed into flooded fields. In the tropics, water temperatures often exceed the optimum for this method of establishment. At Coastal Plains Research Station (12°33'S 131°20'E) near Darwin, N.T., Australia, a rice field environment was simulated using tanks. Diurnal temperature profiles were measured in 10- and 30-mm layers of clear water with and without an evaporation suppressant, and turbid water, for the months of December and June. The patterns of temperature in clear and turbid water were consistently different at both times of the year. Marked temperature gradients (up to 1°C/cm) occurred by day in turbid water, with maxima at the air-water interface, but gradients in clear water were invariably very small. The physical theory of radiation absorption and thermal transport in a water layer is presented and used to interpret the observations of temperature. A crucial factor in the interpretation relates to the conditions which govern the onset of convective motion. The analysis indicates that the temperature in clear water layers will be uniform throughout at all times and for all depths used in rice culture. The same will be true in turbid water at night, but during the day temperature will decrease with depth.

68-69:02D-011
VAPOR LOSSES THROUGH SOIL MULCH AT DIFFERENT WIND VELOCITIES,
Acharya, C. L., and Prihar, S. S.
Punjab Agricultural University, Hissar, India, Department of Soils.
Agronomy Journal, Vol. 61, No. 5 p 666-668, September-October, 1969. 3 tab, 3 fig, 6 ref.

Descriptors: *Soil moisture, *Mulching, *Evaporation control, *Wind velocity, Water vapor.
Identifiers: Mulch porosity, Mulch thickness.

Rates of water vapor loss, E, through surfactant treated soil mulch of varying porosity and thickness were measured in pots exposed to various wind velocities under a wide range of evaporative demand. Empirical values of constant 'BD' obtained from the relation $Eo/E = 1+BDZn$ (where Eo is the potential evaporation from the medium and Zn is the thickness of mulch) were expressed in terms of wind velocity (X_1) and porosity of mulch (X_2). Multiple regression of the type $BD = q + q_1X_1 + q_2X_2$ was used to express BD as a function of wind velocity and porosity of mulch within the range of linearity of the relation $Eo/E = f\ (Zn)$.

68-69:02D-012
DETERMINATION OF THE SEASONAL AND MONTHLY EVAPORATION NORMALS FROM AGRICULTURAL FIELDS FROM OBSERVATIONS AT A NETWORK OF STATIONS,
Kuz'min, P. P., Fedorov, S. F., and Pomytkin, B. A.
State Hydrological Inst., Leningrad, USSR.
Trans. from Trudy GGI, No. 151, p 12-29, 1968. Soviet Hydrology, Selected Paper No. 3, p 206-221, 1968. 3 fig, 19 ref, 5 append.

Descriptors: *Evaporation, *Evapotranspiration, Humidity, Climatology, Energy budget, Meteorology, Soil moisture, Plants, Crops Vegetation effects.
Identifiers: *USSR.

A method is given for determining long-period average seasonal and monthly evaporation from agricultural fields during the warm period, May-September. The method uses an empirical graphic relationship between crop evaporation coefficient and the radiational aridity index. Calculations of evaporations are tabulated and compared with evaporimeter measurements in all the major geographic regions of the USSR.

68-69:02D-013
SIMULATION OF EVAPORATION FROM CONSTANT SOURCE WITH FINITE AREAS,
Shih, Chau, and Dracup, John A.
California University, Los Angeles.
Water Resources Research, Vol. 5, No. 1, p 281-290, February 1969. 8 fig, 1 tab, 9 ref.

Descriptors: *Evaporation, *Computer models, Mass transfer, Simulation analysis, Heat budget, Hydrologic budget, Digital computers, Analog computers, Resistance networks, Mathematical models, Convection, Diffusion, Lakes, Reservoirs, Winds, Solar radiation.
Identifiers: *Hybrid computer methods.

Evaporation from finite areas with constant sources is determined by simulating the mass transfer equation. The equation of mass transfer in a turbulent atmosphere describes the movement of mass, water vapor, and momentum. The process of transferring water vapor by evaporation from a constant source can be analyzed by the solution of this diffusion equation. A hybrid computer simulation method to solve the three-dimensional nonuniform diffusion equation is described. The proposed technique can handle any geometric configuration of lakes and reservoirs. Using a finite difference method, the partial differential equation is transformed into a set of algebraic equations and the node equations of a passive resistance network plane makes the hybrid computer simulation technique applicable to solve problems of this type. A vertical plane, perpendicular to the direction of the wind, is simulated by a passive resistance network. The problem is solved by moving the vertical plane in the direction of the wind. Obtaining the solution using a simulation technique involves a repetitive process of observing voltages on the simulation network. The entire process is performed in the hybrid computer system using the digital computer as the control. This is a general method available to analyze the evaporation phenomena using a mathematical solution of the diffusion equation.

68-69:02D-014
EVAPORATIVE COOLING OF HEATED IRRIGATION WATER BY SPRINKLER APPLICATION,
Cline, J. N., Wolf, M. A., and Hungate, F. P.
Battelle Memorial Institute, Richland, Washington.
Water Resources Research, Vol. 5, No. 2, p 401-406, April 1969. 1 fig, 3 tab, 20 ref.

Descriptors: *Heated water, *Sprinkler irrigation, Temperature control, Cooling, Irrigation, Evaporation, Crop production.
Identifiers: *Impact temperature, Relative humidity, Nozzle pressure, Evaporative cooling.

Heated water was cooled rapidly to impact temperatures that produce optimum growth in plants by applying the water with a standard irrigation sprinkler. Maximum cooling was observed nearest the sprinkler, where the smallest droplets were measured, and temperatures and mean diameters generally increased with distance from the source. Impact temperatures of the water droplets approached but did not reach wet bulb temperatures. Water as hot as 50 deg C was cooled to droplet temperatures of 25 deg C or less when the sprinklers were operated in an associated arid climate and at line pressures greater than 25 psi. A theoretical treatment correlated well with one selected set of experimental data and with predicted cooling rates for specified droplets in several typical atmospheric conditions and one untypical condition for an arid climate. Only under the condition of high relative humidity at a given ambient temperature does it appear that cooling might be insufficient to produce usable sprinkler water from 50 deg C supply water for crop production.

68-69:02D-015
A MODEL FOR SIMULATING SOIL WATER REGIME IN ALTERNATING FALLOW-CROP SYSTEMS,
Fitzpatrick, E. A., and Nix, H. A.
Commonwealth Scientific and Industrial Research Organization, Canberra, Australia, Div. of Land Research and Regional Survey.
Agricultural Meteorology, Vol. 6, No. 5, p 303-319, September 1969. 8 fig, 1 tab, 36 ref.

Descriptors: *Model studies, *Evaporation, *Evapotranspiration, *Soil water, *Fallowing, Crop production, Semiarid climates, Cotton, Sorghum, Wheat, Water loss, Water balance, Meteorological data, Climatology, Soil-water-plant relationships.
Identifiers: *Soil water reserves, Agronomic practices, Queensland, Australia.

A set of simple working functions depicting evaporative loss from an alternating fallow-crop system was used in a model for simulating soil water regime in sub-humid to semi-arid central Queensland. Despite inadequacies in the data, the model closely simulated changes over time in the soil water regime. This was achieved by using distinctive functions for fallowed and cropped intervals and by making evapotranspiration rates dependent upon status of available soil water and stage of crop development. Data were sufficient to allow formulation of functions for cotton, sorghum, and wheat. The model makes provision for future refinements in data and appears promising as a basis for assessing effects of varied agronomic practices on available soil water reserves.

68-69:02D-016
THE EVAPOTRANSPIRATION COMPONENT OF A PASTORAL EXPERIMENTAL CATCHMENT,
Dunin, F. X.
Soil Conservation Authority, Kew, Australia.
Journal of Hydrology, Vol. 7, No. 2, p 147-157, January 1969. 1 fig, 5 tab, 3 ref.

Descriptors: *Evapotranspiration, *Hydrologic budget, Mathematical models, Water balance, Antecedent precipitation, Runoff, Moisture stress, Rainfall-runoff relationships, Demonstration watersheds, Model studies, Soil water movement.
Identifiers: *Australia, Potential evapotranspiration, Parwan Experimental Area (Australia).

The amount of evapotranspiration occurring from a pastoral catchment was determined by an assessment of the hydrologic balance within the catchment. A measure of the variable for changes in water content was achieved by the evaluation of soil storage deficits antecedent to runoff events. Thus, the intervals of time for the determination of the amounts of evapotranspiration were confined to periods between runoff events. For those intervals when the index of topsoil moisture stress did not exceed a pF value of 3.5, a ratio of one existed between measured evapotranspiration and the index of potential evapotranspiration. With the use of this ratio in conjunction with the soil moisture record, variations in rates of evapotranspiration were presented for the years 1963 to 1966. Such data indicated that the prevailing land-use was inefficient in its consumption of water.

68-69:02D-017
PREDICTING EFFECTS OF WATER SHORTAGE ON CROP YIELD,
Stewart, J. Ian, and Hagan, Robert M.
California University, Davis, Dept of Water Science and Engineering.
Journal of the Irrigation and Drainage Division, ASCE, Vol. 95, No. IR1, Proc Paper 6443, p 91-104, March 1969. 9 fig, 14 ref.

Descriptors: *Crop production, *Water shortage, *Water utilization, *Water allocation (Policy), *Planning, Evapotranspiration, Alfalfa, Sorghum, Wheat, Soil moisture, Water management, Precipitation (Atmospheric), Irrigation efficiency, Moisture deficit, Water supply, Data collections.

This paper discusses relationships existing between water use, expressed as evapotranspiration, and yields of alfalfa, wheat and grain sorghum. Data assembled from a number of sources, was used to tentatively formulate water production functions in both absolute and relative forms. A detailed hypothetical example of use of such a function for water allocation and management planning for maximization of wheat production during a water shortage was given. The example showed the disproportionate importance which can be attached to stored soil moisture and in-season precipitation when maximization of total production is the goal. Conclusions were basically that definition of water use-yield relationships can be done for certain crops from experimental data, and that the functions thus produced would greatly assist planners at all levels in making water allocation and management decisions, particularly in situations of water shortage.

68-69:02D-018
THE EFFECT OF ALBEDO ON THE EVAPOTRANSPIRATION RATE,
Seginer, I.
Cornell University, Ithaca, N.Y.
Agricultural Meteorology, Vol. 6, p 5-31, 1969. 12 fig, 3 tab, 20 ref.

Descriptors: *Evapotranspiration, *Irrigation, *Albedo, *Radiation, Energy budget, Evaporation, Heat flow, Energy balance, Model studies.
Identifiers: Long wave radiation.

The problem was to evaluate the possibility of reducing the evapotranspiration of an irrigated field by increasing its reflectivity to incoming radiation. A numerical computation approach was used to solve the differential equations governing the transfer phenomena in a horizontally homogeneous atmospheric boundary layer and underlying soil. A few preliminary tests showed that although wind velocities were not accurately predicted, the effect of such inaccuracies on the energy budget results was not significant. Comparisons of calculated results for fields with natural albedo (0.25) and fields with albedo artificially increased to 0.40, indicated the following: (1) Under a clear sky, the relative reduction in net radiation due to the treatment was about 30%, as compared with only 20% reduction in the solar radiation absorbed at the surface; (2) The major factors affecting the saving of water were the albedo and the wetness of the surface. Wind, surface roughness and thermal stratification were of only secondary importance; (3) The saving in water due to the treatment was calculated to be roughly 30% for all wetness conditions.

68-69:02D-019
CONTROLLING TRANSPIRATION IN ASPEN WITH PHENYLMERCURIC ACETATE,
Hart, G. E., Schultz, J. D., and Coltharp, G. B.
Utah State University, Logan.
Water Resources Research, Vol. 5, No. 2, p 407-412, April 1969. 3 fig, 3 tab, 10 ref.

Descriptors: *Evapotranspiration control, *Transpiration control, Stomata, Water conservation, Forests, Water yield improvement, Watershed management, Forest management, Water management (Applied).
Identifiers: Phenylmercuric acetate, Aspen trees.

A 0.0001 M spray of phenylmercuric acetate was applied by helicopter to part of an aspen stand in northern Utah in June, 1967. The natural fluttering action of the aspen leaves facilitated delivery of the spray to the stomata-bearing underside of the leaves. Nine days after treatment, stomata width on treated trees averaged 2.4 microns as compared with 4.0 microns measured on untreated trees. Heat pulse measurements indicated reduction in daylight sap velocity from 11 cm/hr to 6 cm/hr. Seasonal soil moisture depletion was not significantly affected, although the pattern of water usage was delayed for about 6 weeks on the treated area.

68-69:02D-020
THE CLIMATOLOGY OF SOIL MOISTURE, EVAPORATION, AND NON-MOISTURE STRESS DAYS FOR CORN IN IOWA,
Dale, Robert F.
Environmental Science Services Administration, Rockville, Maryland.
Agricultural Meteorology, Vol. 5, No. 2, p 111-128, March 1968. 12 fig, 7 tab, 12 ref.

Descriptors: *Climatology, *Corn (Field), *Crop production, *Soil moisture, *Evaporation, Moisture availability, Moisture stress, Evapotranspiration, Weather, Precipitation (Atmospheric), Iowa, Corn Belt, Estimating, Phenology, Soil-water-plant relationships, Variability.
Identifiers: *Potential evapotranspiration, *Non-moisture stress.

The study is concerned with the possibility of utilizing for regional agricultural planning a method which considers the interaction upon corn crops of potential evapotranspiration, soil moisture, and ease of extraction of available water. Climatology of the number of days with no moisture stress in the critical growth period of corn is given for four Iowa locations. Climatology of the input variables is described for these same four stations. Input variables consist of evaporation, precipitation, and soil moisture under corn. Using the non-stress day climatology it was demonstrated that areas of higher than average precipitation had a higher frequency of unfavorable weather and lower corn yields caused by moisture stress.

68-69:02D-021
USE OF ATMOMETERS IN ESTIMATING EVAPOTRANSPIRATION,
Shannon, John W.
California Dept of Water Resources, Sacramento.
Journal of the Irrigation and Drainage Division, ASCE, Vol. 94, No. IR3, Proc Paper No. 6120, p 309-320, September 1968.

Descriptors: *Atmometers, Instrumentation, Evaporation, *Climatic data, *Evapotranspiration, Evaporation pans, Water requirements, Data collections, Energy, *Monthly, *Seasonal, Water loss.
Identifiers: Evaporative demand, Crop coefficients.

Studies conducted by the California Department of Water Resources during the past 10 years show that Livingston black and white spherical atmometers provided a practical means of estimating monthly and seasonal evapotranspiration. The difference of evaporation between the black and white atmometers was affected primarily by short wave energy, whereas evaporation from either the black or white atmometer provided an index of the total amount of energy available for evapotranspiration. Various studies were made, the results of which indicated that the type of background has little effect upon the difference in evaporation between the black and white atmometers. Monthly crop coefficients were developed for some of the principal crops in the Central Valley of California, which provided evapotranspiration estimates consistently as good as or better than could be obtained using coefficients developed from United States Weather Bureau Class A evaporation pan data.

68-69:02D-022
POTENTIAL EVAPOTRANSPIRATION AS INFLUENCED BY WIND,
Skidmore, E. L., Jacobs, H. S., and Powers, W. L.
Kansas State University, Manhattan.
Agronomy Journal, Vol. 61, No. 4, p 543-546, July-August, 1969. 6 fig, 1 tab, 19 ref.

Descriptors: Evaporation, *Evapotranspiration, *Winds, Wind velocity, Wind speed, Agronomy, Crops, Water requirements, Great Plains, Effects, Agriculture, Energy balance, Hydrology, Bibliographies, Soil science.
Identifiers: *Potential evapotranspiration, Hydrologic models, Net radiometer, Van Bavel method.

The contribution of wind to calculated potential evapotranspiration was investigated with applications for the climate of the Great Plains. A revised combination model proposed by van Bavel for computing instantaneous potential evapotranspiration was used. The model contains 2 terms that are expressions for the portions of potential evapotranspiration primarily caused by net radiation and wind. With ambient water vapor pressure 20 mb, temperature 30 deg C, wind 2, 4, and 6 m/sec at 2 m with a roughness length of 1 cm, the contribution of wind-dominant term to evaporation from a wet surface is 0.15, 0.30, and 0.45 mm/hr, respectively. At 10-mb vapor pressure and the same temperature, the corresponding evaporation rates are 0.22, 0.43, and 0.65 mm/hr. On representative and consecutive nonwindy and windy days at Manhattan, Kansas (average daily windspeeds at 45 cm were 0.88 and 2.26 m/sec), the wind-dominant term contributed 33 and 113% respectively, as much as the radiation-dominant term to the total calculated potential evapotranspiration. For these 2 days, the ratio of potential evapotranspiration to net radiation was 0.98 and 1.60.

68-69:02D-023
EVAPOTRANSPIRATION AND MICROCLIMATE OF IRRIGATED PASTURES AND ALFALFA UNDER HIGH ALTITUDE CONDITIONS,
Burman, R. D., and Loudon, T. L.
Wyoming University, Laramie, Dept of Agricultural Engineering.
American Society of Agricultural Engineers, Transactions, Vol. 11, No. 1, p 123-125, January-February, 1968. 6 fig, 6 tab, 5 ref.

Descriptors: *Evapotranspiration, *Microclimatology, *Irrigated land, *Irrigation effects, *Pastures, Alfalfa, Wheatgrasses, Arid lands, Wyoming, Altitude, Air circulation, Cloud cover, Crop response, Energy budget, Solar radiation.
Identifiers: *Energy-balance components, *Farson Pilot Farm, Wyoming, *Cool steppes, *Red Desert, Wyoming, Eden Project, Ryegrasses.

Studies were undertaken in 1962-1966 to investigate evapotranspiration and microclimate of high-altitude irrigated pastures. It was found that evapotranspiration from ryegrass-alfalfa pastures was higher than evapotranspiration from wheat-grass-alfalfa pastures, except for a 1-hr midday period when it was lower for the ryegrass-alfalfa mixture. The greatest evapotranspiration difference between crops occurred in the afternoon. Crop evapotranspiration was influenced considerably more by sky conditions than by application of irrigation. Energy-balance components were much higher in bright sunshine than under cloudy skies. Air over the pasture was unstable until late afternoon, with most of the evapotranspiration occurring during the period of instability.

68-69:02D-024
PAN EVAPORATION AND EVAPOTRANSPIRATION FROM CLIMATIC DATA,
Christiansen, Jerald E.
Utah State University, Logan.
Journal of the Irrigation and Drainage Division, ASCE, Vol. 94, No. IR2, Proc Paper No. 5988, p 243-265, June 1968. 13 tab.

Descriptors: *Evaporation pans, *Evapotranspiration, *Climatic data, *Mathematical models, Equations, Data collections, *Analytical techniques, Temperature, Solar radiation, Wind velocity, Humidity, Elevation.

A formula was developed at Utah State University for estimating pan evaporation from extraterrestrial radiation and climatic data. This formula utilizes climatic data of the type most readily available. Tables are presented to simplify the application of the formula where electronic computers are not used. Three formulas for estimating evapotranspiration for several agricultural crops using as the principal parameters either extraterrestrial radiation, pan evaporation or measured incident radiation, together with climatic data, were also presented. The planning and design of irrigation systems in arid regions requires, at the outset, an estimate of water requirements which this formula can help to supply.

68-69:02D-025
ANTITRANSPIRANTS RESEARCH AND ITS POSSIBLE APPLICATION IN HYDROLOGY,
Davenport, David C., Hagan, Robert M., and Martin, Paul E.
California University, Davis.
Water Resources Research, Vol. 5, No. 3, p 735-743, June 1969. 4 fig, 1 tab, 33 ref.

Descriptors: *Transpiration control, *Water conservation, Chemcontrol, Stomata, Water yield, Water management (Applied), Watershed management.
Identifiers: *Antitranspirants.

Research on antitranspirants may have application in increasing the yield of water from watersheds by reducing transpirational losses from vegetation under certain environmental conditions. There are 3 broad groups of antitranspirants: (1) reflecting materials that decrease the heat load on the leaf, (2) film-forming materials that hinder the escape of water vapor from the leaf, and (3) stomata-closing materials that increase stomatal resistance. Antitranspirants are most effective in decreasing transpiration when other resistances in the passage of water to the roots, through the plant, and to the atmosphere are not great, when there is good coverage of the stomatal bearing leaf surfaces (except for reflecting materials), when new foliar growth following treatment is minimal, and when optimum concentrations and application rates are used.

68-69:02D-026
AN INDEX OF CROP WATER STRESS RELATED TO WHEAT AND GRAIN SORGHUM YIELDS,
Nix, H. A., and Fitzpatrick, E. A.
CSIRO, Canberra (Australia), Division of Land Research and Regional Survey.
Agricultural Meteorology, Vol. 6, No. 5, p 321-337, September 1969. 4 fig, 4 tab, 21 ref, 3 append.

Descriptors: *Moisture stress, *Crop production, *Evapotranspiration, *Soil-water-plant relationships, *Soil water, Moisture deficit, Climatic data, Rainfall, Plant physiology, Wheat, Sorghum, Environmental effects, Data collections, Regression analysis, Phenology.
Identifiers: *Stress index, *Queensland, Australia.

Soil-water regimes for wheat and grain sorghum were studied in experiments in central Queensland. Analysis of the ratio of estimated actual to potential evapotranspiration at defined intervals of growth for both crops revealed a critical growth period from ear emergence to early grain development. Ratios calculated for this 'critical' period correlated more closely with yield than other indices used to characterize crop water environment. A simple index incorporating available soil water supply and potential evaporative demand gave highly significant correlations with yields. This index accounted for 60-83% of the yield variation within the different varieties under study. After checking these findings against wheat yield data in Queensland for the 1952-1965 period, it would appear than intra-seasonal and year-to-year variation in yield is largely a function of anthesis date in relation to the then prevailing environmental moisture stress.

68-69:02D-027
EVAPOTRANSPIRATION AS AFFECTED BY PLANT DENSITY AND WATER-TABLE DEPTH,
Stewart, E. H., Browning, J. E., and Burt, E. O.
Plantation Field Laboratory, Fort Lauderdale, Florida.
Transactions of the American Society of Agricultural Engineers, Vol. 12, No. 5, p 646-647, September-October 1969. 3 fig, 1 tab, 3 ref.

Descriptors: *Evapotranspiration, *Water balance, *Bermudagrass.
Identifiers: *Florida.

Studies were made to determine the relation of evapotranspiration to percentage of plant cover and depth to water table for use in water budget studies. A 3-year differential water-table study was made using Tifway bermudagrass planted in 12 nonweighing evapotranspirometers. The installations consisted of 12 waterproof rectangular tanks, 5ft deep, each having a plot area of approximately 1/1000 acre. Plant-cover studies were made using 0-, 1/3-, 2/3-, and full-sod cover treatments in three replicates. A modified randomization of treatments was used so that the three replicate plots assigned to each of the four plant-cover treatments included the three differential water-table level plots used in the previous study. The plant cover study was a 3-year study with depth to water-table maintained at a depth of 24 in. the first year, 36 in. the second, and 12 the third. A linear relationship exists between degree of plant cover and annual evaportranspiration of Tifway bermudagrass grown on Arzel fine sand with 12-, 24-, and 36-in. water tables. Evapotranspiration increased with sod cover at water-table depths of 24 and 36 in., but decreased slightly for water table depth of 12 in. The ratio between evapotranspiration from no sod or partial sod and full sod was related to the depth to water table and the amount, frequency and distribution of rainfall.

68-69:02D-028
ROLE OF EVAPORATION IN THE MIGRATION OF SALTS INTO THE ATMOSPHERE,
Nemeryuk, G. Ye.
Groskiy Agricultural Institute, Ordzhonikidze.
Soviet Hydrology: Selected Papers, No. 6, p 618-625, 1969. 7 tab, 8 ref.

Descriptors: *Evaporation, Evapotranspiration, Transpiration, Sublimation, *Salts, *Chlorides, Chemistry of precipitation, *Atmosphere, Sea water.
Identifiers: *Hydrochemistry.

The purpose of this study is to verify the validity of the assumption that salts are removed during evaporation from the water surface in relation to the problem of the origin of salts found in atmospheric precipitation. The ion composition of vapor of solutions was studied. The migration of salts with water vapor was established in two ways. First, an isothermal distillation of Na_2CO_3, Na_2SO_4, NaCl, and $CaCl_2$ solutions was accomplished at room temperatures in a closed space in the laboratory in the presence of hygroscopic substances. Tests were run upon completion of the experiments to determine the volumes of salts transported. In the field, vapor from natural soil and plant solutions was collected in chambers where the vapor condensed on a surface cooled with dry ice. Upon completion of the experiment, a chemical analysis of the condensates was performed according to recommended methods. Evaporation is an important link in salt exchange through the atmosphere under natural conditions. Migration of salts with water vapor differs from the mechanism by which salts enter the atmosphere with sea spray. The reason for the migration of ions with water vapor is their hydration and apparently also exchange adsorption between liquid and gaseous phases.

68-69:02D-029
DEVELOPING A PHYSICAL-CHEMICAL MODEL FOR A PLANT GROWTH SYSTEM,
Chen, L. H., Huang, B. K., and Splinter, W. E.
North Carolina State University, Raleigh, Dept of Biological and Agricultural Engineering.
Transactions of the American Society of Agricultural Engineers, Vol. 12, No. 5, p 698-702, September 1969. 8 fig, 9 ref.

Descriptors: *Model studies, *Plant growth, Growth rates, Plant growth substances, Plant Physiology, *Photosynthesis, Energy conversion, Respiration.

A model is developed which describes plant growth as a function of photosynthesis and respiration. The modeling of plant growth was considered essential for systems engineering of agricultural production. A functional relationship between photosynthesis, respiration and growth was developed. The model showed considerable promise, the general relationship between growth rate constant and each environmental factor were conformable to experimental results.

68-69:02D-030
PLANT GROWTH-EVAPOTRANSPIRATION RELATIONS FOR SEVERAL CROPS IN THE CENTRAL GREAT PLAINS,
Hanks, R. J., Gardner, H. R., and Florian, R. L.
Utah State University, Logan, Dept of Soils and Meteorology.
Agronomy Journal, Vol. 61, No. 1, p 30-34, January-February 1969. 5 fig, 1 tab, 9 ref.

Descriptors: *Evaporation, Lysimeters, Transpiration, Crops, Runoff, Percolation, Sorghum, Wheat.
Identifiers: Great Plains.

Lysimeters, which eliminated runoff and percolation below 90 cm, caused about 10 cm of additional water to be available for growth of grain sorghum in 1967. This additional water doubled yields, with an increase in evapotranspiration of only 50 percent. Evaporation from soil in the lysimeter was only 32% of the evapotranspiration, compared with 50% for the soil surrounding the lysimeter. Evaporation from the soil within a winter wheat crop during the actively growing period in the spring, was estimated to be 15 and 37% of evapotranspiration for 1966 and 1967 respectively. Evaporation from the soil within the actively growing crop was estimated to be 34 and 20% of the evapotranspiration for oats and millet, respectively. Estimates of the amount of water evaporated from the soil within a crop allowed for estimation of transpiration from measurements of evapotranspiration. This data indicate that production and transpiration are directly related in this dryland area as de Wit (3) suggests.

SECTION III

WATER CYCLE - STREAMFLOW AND RUNOFF (Group 02E)

68-69:02E-001
A METHOD OF ANALYZING TRANSIENT FLUID IN MULTILAYERED AQUIFERS,
Javandel, Iraj, and Witherspoon, Paul A.
Pahlavi University, Shiraz, Iran.
Water Resources Research, Vol. 5, No. 4, p 856-869, August 1969. 10 fig, 13 ref.

Descriptors: Transients, *Unsteady flow, *Aquifers, Methodology, Theis equation, Fluid flow, *Groundwater flow, Anisotrophy, Permeability, Drawdown, Numerical analysis, Groundwater, Pumping, Analysis.
Identifiers: *Transient flow, Finite element method, Two-part aquifers, Boundary conditions.

A new approach to transient fluid flow in multilayered aquifers of anisotropic systems was developed using the finite element method. This is a numeric technique in which an initial boundary value problem is converted to a variational problem and applied to a discrete system of elements. The method was used to investigate potential distributions in multilayered aquifers of finite radial extent being pumped at constant rate using completely penetrating wells. An analysis of 2-layer systems with permeability contrasts of up to 100:1 indicates that at early time the drawdown behavior can vary significantly from the Theis solution, depending on where observations are made. As time increases, results converge on the Theis solution, regardless of the permeability contrast. A 13-layer aquifer containing either isotropic or anisotropic layers was also examined. Results are in general agreement with the behavior for 2-layer systems.

68-69:02E-002
DESIGN OF RECIRCULATING IRRIGATION SYSTEMS,
Bondurant, J. A.
Agricultural Research Service, Kimberly, Idaho.
American Society of Agricultural Engineers, Transactions, Vol. 12, No. 2, p 195-198, 1969. 6 fig, 3 ref.

Descriptors: *Runoff, *Water reuse, *Irrigation systems, *Surface irrigation, *Irrigation efficiency, Irrigation water, Idaho, Farm equipment, Operating costs, Irrigation engineering, Agricultural engineering, Equations, Arid lands, Design criteria, Pumping plants, Cost analysis, Flow rates, Water utilization.
Identifiers: *Recirculating irrigation systems.

Irrigation is necessary for many crops in arid or semiarid regions. When water costs are high or when it is desirable to control surface flow of silt and chemical contaminants in irrigation runoff water, a recirculation system may be considered. When irrigation runoff is collected it should be recirculated to a different field. Maximum improvement in efficiency is achieved by using stored runoff water to reduce stream size for cutback irrigation. A design example is given for an Idaho farm of 105 irrigated acres. A method is presented for determining amount and rates of runoff and time and size of cutback. Since annual operating costs depend to a large extent on design and efficiency of the pumping installation, great emphasis is placed on these factors. The necessary design data are listed and the equations for design calculations are given.

68-69:02E-003
A COMPARISON OF NITROGEN LOSSES FROM UREA AND AMMONIUM NITRATE IN SURFACE RUNOFF WATER,
Moe, P. G., Mannering, J. V., and Johnson, C. B.
Purdue University Agricultural Experiment Station, Lafayette, Indiana.
Soil Science, Vol. 105, No. 6, p 428-433, 1968. 3 fig, 3 tab, 9 ref.

Descriptors: *Nitrogen, *Surface runoff, *Ammonium compounds, *Urea.

Small plots were established on a Zanesville silt loam having a 13% slope and a fragipan at 24-34 in. Half the plots were maintained in an established fescue sod clipped to a height of 3-4 in. and the other half were second-year fallow plowed in mid-May and disced two times in mid-July. Pellets of ammonium nitrate and urea were broadcast on the surface at rates equivalent to 400 lbs/acre of N. A rainfall simulator was used to apply 2½ in. of water at preselected times. Runoff was sampled at 5-minute intervals and analyzed for ammonium, nitrate, and urea N. Total N loss from all plots ranged between 2.4 - 12.7% of the applied N. Urea was present only in runoff from sod plots; most of the area was rapidly hydrolyzed in the soil. NH_4^+-N was less susceptible to runoff loss in urea plots than ammonium nitrate plots, probably because urea moved more deeply into the soil with water than the highly ionized ammonium nitrate.

68-69:02E-004
GEOMETRIC SHAPING AND CONTOURING OF LAND AS RELATED TO POTENTIAL FOR SURFACE-WATER STORAGE,
Doty, C. W., and Wiersma, J. L.
Agricultural Research Service, Brookings, South Dakota.
American Society of Agricultural Engineers, Transactions, Vol. 12, No. 4, p 325-332, May-June, 1969. 8 fig, 3 tab, 12 ref.

Descriptors: *Water storage, *Surface runoff, *Erosion control, *Water conservation, *Soil conservation, Terracing, Contour farming, Runoff, South Dakota, Corn Belt, Shape, Storage capacity, Planting management, Crop production.
Identifiers: *Geometric shaping, *Listing, *8-row bedding.

In the Corn Belt 60-75% of annual runoff and 75-90% of annual erosion occurs during the first 60 days of the corn season (planting to second cultivation). Since it is impossible to apply a crop canopy to the soils, surface configurations on the land are necessary to store water and reduce runoff. The study was designed to discover which of six various geometric shapes had the greatest water-holding capacity. This capacity would determine ability to decrease runoff and erosion. It was concluded that listing and 8-row bedding were the most beneficial configurations, provided they were coupled with very accurate contouring.

68-69:02E-005
CHLORINATED INSECTICIDES IN RUNOFF WATER AS AFFECTED BY CROP ROTATION,
Epstein, E., and Grant, W. J.
Agricultural Research Service, Orono, Maine.
Soil Science Society of America Proceedings, Vol. 32, No. 3, p 423-426, May-June, 1968. 6 tab, 20 ref.

Descriptors: *Pesticides, *Runoff, *Rotations, Water pollution sources, Path of pollutants, DDT.
Identifiers: Crop rotation effects.

The concentration and amounts of 3 chlorinated insecticides were lower in runoff from a rotation system of potato, oats, and sod than under continuous potato cropping. Runoff samples from natural runoff plots were collected following each storm, and the amounts of DDT, endrin, and endosulfan were analyzed with a gas chromatograph. The amounts of pesticides in runoff were small compared to the amount applied. The concentrations of the insecticides in the runoff (soil-water suspension) were generally greater than those found in the settled soil (sludge).

68-69:02E-006
EFFECTS OF CULTIVATION AND GRASS ON SURFACE RUNOFF,
Dragoun, Frank J.
Agricultural Research Service, Coshocton, Ohio.
Paper No. H-28, presented at 50th Annual Meeting of American Geophysical Union, Washington, D.C., April 21-25, 1969. 13 p, 3 fig, 3 tab, 7 ref.

Descriptors: *Rainfall-runoff relationships, *Cultivation, *Surface runoff, *Water yield improvement, Grasslands, Crops, Land use, Watersheds (Basins), Runoff, Nebraska, Great Plains, Watershed management.
Identifiers: Hastings, Nebraska.

More than a million acres of marginal cropland have been converted to permanent vegetation in the Great Plains, and conversion is proposed for many more acres. This report presents results of research showing the effect of drastic changes in land use on watershed surface runoff from 4-acre watersheds near Hastings, Nebraska. Surface runoff was significantly reduced two years after converting marginal cultivated fields to perennial grass, and was representative of runoff from native meadow after the third year. Conversely, runoff increased greatly the first year after native meadow was placed in cultivation.

68-69:02E-007
RUNOFF VOLUME PREDICTION FROM DAILY CLIMATIC DATA,
Knisel, Walter G., Jr., Baird, Ralph W., and Hartman, Monroe A.
Agricultural Research Service, Riesel, Texas.
Water Resources Research, Vol. 5, No. 2, p 84-94, February 1969. 8 fig, 9 ref.

Descriptors: *Rainfall-runoff relationships, *Soil moisture, *Runoff forecasting, Model studies, Mathematical models, Digital computers, Hydrologic budget, Discharge (Water), Infiltration, Inflow, Streamflow, Water balance, Evaporation, Precipitation intensity, Duration curves, Hydrograph analysis, Hydrographs.
Identifiers: Soil moisture reservoir, Runoff prediction.

A two-soil-moisture-reservoir model is developed to improve the estimate accuracy of a runoff-volume-prediction model. Soil moisture accounting in the two reservoirs is an intermediate step to runoff prediction. A decay-type function describes the moisture depletion between days of rainfall. The moisture depletion constant in the function varies by season with soil moisture, pan evaporation, and mean daily temperature. The runoff prediction equation relates runoff to rainfall and soil moisture at the beginning of the storm. Computed runoff volumes are compared with values observed on a 3-acre native grass-meadow watershed for an 11-year period. Accumulated computed amounts for the period agree within 1% of the accumulated observed amounts.

68-69:02E-008
APPLICATION RATES AND RUNOFF IN CENTER-PIVOT SPRINKLER IRRIGATION,
Kincaid, D. C., Heermann, D. F., and Kruse, E. G.
Colorado State University, Fort Collins, Dept of Agricultural Engineering.
American Society of Agricultural Engineers, Transactions, Vol. 12, No. 6, p 790-794, 797, November-December, 1969. 9 fig, 4 tab, 4 ref.

Descriptors: *Rates of application, *Application methods, *Sprinkler irrigation, *Runoff, *Soil types, Irrigation systems, Irrigation practices, Irrigation design, Irrigation efficiency, Slopes, Soil surfaces, Estimating, Data collections, Consumptive use, Soil water, Discharge (Water), Infiltration.
Identifiers: *Center-pivot sprinkler systems, *Soil intake rates, *Potential runoff, *Actual runoff.

Application rates and expected runoff in relation to different soil types were analyzed for the center-pivot sprinkler irrigation system. Potential runoff theory using modified experimental intake constants was applied to field situations. Results were compared with experimental estimates of actual runoff. Given a certain amount of potential runoff from a particular area, actual runoff depends on slope, roughness of soil surface, and position with respect to other runoff areas. Special attention should be given to soil surface conditions and intake rates when applying center-pivot systems to sloping lands.

68-69:02E-009
QUICK-RETURN SUBSURFACE FLOW,
Jamieson, D. G., and Amerman, C. R.
Agricultural Research Service, Beltsville, Maryland, Hydrograph Lab.
Journal of Hydrology, Vol. 8, No. 2, p 122-136, June 1969. 1 tab, 16 ref.

Descriptors: *Soil water movement, *Subsurface runoff, *Routing, *Surface-groundwater relationships, Water storage, Model studies, Mathematical models, Simulation analysis, Infiltration, Overland flow, Percolation.
Identifiers: Quick-return subsurface flow.

One of the least understood of all hydrologic problems is that of lateral flow in the soil's upper horizons. The nature and quantity involved in this quick-return flow are unkown and have to be inferred from the shape of the observed hydrograph. An attempt has been made to mathematically simulate the flow phenomenon using rainfall as input and a system of interconnected, nonlinear reservoirs as the operator.

SECTION IV

WATER CYCLE - GROUNDWATER (Group 02F)

68-69:02F-001
DISPERSION AT THE INTERFACE OF MISCIBLE LIQUIDS IN A SOIL,
Li, W. H., and Yeh, G. T.
Syracuse University, Syracuse, N.Y.
Water Resources Research, Vol. 4, No. 2, p 369-377, April 1968. 7 fig, 10 ref.

Descriptors: *Ground water, Porous media, *Saline water, *Dispersion.
Identifiers: *Fick's law, *Miscible liquids.

When two miscible liquids flow through a porous medium (e.g., fresh water and salt water in an aquifer), the dispersion at the interface is described by Fick's law with a velocity-dependent coefficient. In the first part of this paper, the horizontal flow of two liquids is used to demonstrate that the influence of gravity and the effects of the differences in density and viscosity are usually negligible. Then solutions are presented for the dispersion at the interface of liquids in two-dimensional flow.

68-69:02F-002
CONSTRUCTION OF PIEZOMETERS, AND METHOD OF INSTALLATION FOR GROUND WATER OBSERVATIONS IN AQUIFERS,
Obbink, J. Groot.
Commonwealth Scientific and Industrial Research Organization, Merbein, Victoria, Div of Horticultural Research.
Journal of Hydrology, Vol. 7, No. 4, p 434-443, April 1969. 9 fig.

Descriptors: *Piezometers, *Observation wells, *Operation and maintenance, Instrumentation, Well casings, Well filter, Wellpoints, Wells, Well screens, Drilling, Aquifers.
Identifiers: Well drilling, Well jetting (Drilling).

Over the period of 1952-1963, groundwater studies were carried out by C.S.I.R.O. in various irrigation districts in South Australia, Victoria, and New South Wales. Piezometers were installed to observe the behavior of ground water in aquifers underlying these areas. A description is given of 2 types of screens which have been used and the methods of installation by jetting or rotary drilling. A detailed description of jetting equipment is given and the use of both types of screens discussed. The material encountered was recent riverine clays and sand, and one particular piezometer site is illustrated. Testing and maintenance of the installed piezometers are described.

68-69:02F-003
ENTRY VELOCITY CONTROL LIMITS DRAIN SEDIMENTATION,
Willardson, L. S., Fouss, J. L., Reeve, R. C., and Fansey, N. R.
Agricultural Research Service, Brawley, California.
Journal of Irrigation and Drainage Division, ASCE, Vol. 94, No. IR4, December 1968. 4 fig, 1 tab, 10 ref.

Descriptors: *Drainage, *Drains, *Sedimentation, Ground water, Filters, Tiles.

Control of the velocity of water entering a subsurface drain will effectively prevent sedimentation. An anti-sedimentation concept based on the Stokes Law settling velocity of particles is described in detail. The essential element for implementation of the concept is an entrance flow path or channel to the drain in which both the magnitude and direction of the inflow velocity of water are controlled. Laboratory tests are reported for different sized particles, shapes of opening, and cross-sectional areas of flow. Tentative design criteria are suggested. The prevention of sediment entry into drains by this method is not by a filtering process.

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68-69:02F-004
REDUCED SODIUM EXCHANGE CAPCITY IN UNSATURATED FLOW,
Mokady, R. S., and Bresler, E.
National and University Institute of Agriculture, Rehovoth, Israel.
Soil Science Society of America Proceedings, Vol. 32, No. 4, p 463-467, July-August, 1968. 7 fig, 1 tab, 11 ref.

Descriptors: *Ion exchange, Diffusion, Anisotropy, Hydrodynamics.
Identifiers: Flow through porous media.

Flowing water with a reduced degree of saturation seems to reduce the apparent or effective cation-exchange capacity. The experiment was performed by running water through a layered soil, thus obtaining unsaturated flow conditions. It is suggested that the flow direction induces anisotropy with respect to molecular diffusion. The hydrodynamic dispersion in the flow direction is almost unaffected. At the same time, there must be some locations off the main water stream with which there is negligible mixing or molecular exchange by diffusion. One may associate to these isolated locations a prevailing direction normal to the mainstream. In this case, it can be said that the unsaturated flow induces anisotropy on ion transfer by mixing or molecular diffusion.

68-69:02F-005
SOLUTION OF UNUSUAL SUBSURFACE DRAINAGE PROBLEM,
Brand, E. W.
Nottingham University, Nottingham, England.
Journal of the Irrigation and Drainage Division, ASCE, Vol. 94, No. IR2, p 199-221, June 1968. 11 fig, 2 tab, 2 ref.

Descriptors: *Drainage, *Groundwater, *Irrigation, Drawdown , Pumping, Wells, Corrosion, Highways.
Identifiers: Antwerp, Belgium.

Details are given of all the stages in the design of the sophisticated subsurface drainage system in the city of Antwerp, including the execution of extensive field pumping tests, the analysis of the alternative solutions to the problem, and the study of the hydraulics of the horizontal intake pipes adopted to effect the groundwater lowering. The possible effect of precipitation of ferric oxide from the groundwater is considered. This most important factor complicated the design, and necessitated complete submergence of the intake system.

68-69:02F-006
SOME PROBLEMS CONNECTED WITH OPERATION OF DRAINAGE SYSTEMS,
Daishev, T. I., and Sannikov, G. P.
International Commission on Irrigation & Drainage Bulletin, p 15-21, July 1968 - January 1969. 2 tab.

Descriptors: *Drainage, Drainage engineering,* Drainage systems, *Tile drainage, Subsurface drainage, *Freezing, *Weed control, *Herbicides, Muck soils, *Silting, Peat, Reclamation.

This paper considers some factors causing failure of individual parts of a drainage system. Particular attention is paid to the following problems: the influence of kyrogen phenomena on the safety and operation of drainage; protection of channels constructed in soils most subjected to the frost influence; chemical measures for removing undesirable plants from drain channels. The main factors leading to silting of a closed drainage line are as follows: measures for drain protection do not correspond to the nature of silting and physico-mechanical properties of soil and the quality of construction works is not sufficiently high. Frozen mineral soils are permeable depending on moist content during freezing. As to the permeability of frozen peats, it is not yet sufficiently investigated. The main factors defining depth of peat freezing are: daily average negative temperatures in winter; snow cover density and depth; moisture content of soil. To prevent slope deformation caused by freezing and thawing, it is necessary to cover the slope surface with a 15-20 cm layer of soils, which are not subjected to frost influence. Use of chemical methods of weed control instead of mechanical, thermal or biological, reduces expenses by 1.5 - 2.0 times and increases labor productivity by 5 - 10 times.

68-69:02F-007
THE MOVEMENT OF RADIOACTIVE SODIUM AND RUTHENIUM THROUGH A SIMULATED AQUIFER,
Champlin, J. B. F., and Eichholz, G. G.
Georgia Institute of Technology, Atlanta.
Water Resources Research, Vol. 4, No. 1, p 147-158, February 1968. 8 fig, 20 ref.

Descriptors: *Groundwater, *Pollution, *Soils, Radioactivity, Aquifer, Sodium, Potassium, Calcium

The interaction of water solutions with the particulate matter composing a natural aquifer is of steadily increasing interest with the new emphasis on pollution of our natural resources. As a means of studying the contribution made by water to the transport of ionic materials through soils, radioactive solutions were injected into a model aquifer containing 725 kg of sand with dimensions of 1x2x0.25 meters. As the radioactivity passed through the sand, its progress was followed by a collimated Geiger Muller tube situated on the exterior of the bed. The appearance of the radioactivity in the effluent, which marked the arrival of the sodium front, was found to be correlated with an increase in suspended particulate matter, potassium and calcium concentrations, and overall conductivity. Of particular significance was that portion of the radioactivity shown to be related directly to the filterable mass of particles in the effluent, despite the high solubility of the ion used. The results with the sodium were compared with those of similar tests on the movement of trivalent ruthenium, which is not soluble at the pH of the solutions used. Both the sodium and ruthenium studies indicated that a significant amount of radioactivity was transported through the test bed on particulate matter which was large enough to be trapped on 0.45 micron membrane filters.

68-69:02F-008
WATER USE BY COTTON FROM LOW AND MODERATELY SALINE STATIC WATER TABLES,
Namken, L. N., Wiegand, C. L., and Brown, R. G.
Agricultural Research Service, Weslaco, Texas.
Agronomy Journal, Vol. 61, No. 2, p 305-310, March-April, 1969. 4 fig, 4 tab, 11 ref.

Descriptors: *Lysimeters, *Salinity, *Ground water, Saline water, Water table, Pervious soils, Cotton, Irrigation.
Identifiers: *Capillary zone salinity.

A 4-year lysimeter study was conducted to determine the contribution of low to moderately saline, shallow static water tables to the total water use and yield of cotton grown on deep, permeable soils. Water tables controlled at 91-, 183-, and 274-cm depths contributed 51.4, 26.4, and 17.3% of the total water use under the high moisture treatment and 60.6, 48.9, and 39.2% under the low moisture treatment. Total water use consisted of soil profile depletion, rainfall, irrigations, and additions of water to maintain the water tables. Water uptake from the 274-cm water table was strongly related to the salinity level (electrical conductivity of saturated soil extract, EC_0) of the capillary (183- to 274- cm) zone. Lint cotton yields were related to the total amount of water obtained from the table as well as to the salinity level of the capillary zone. Moderate salinity (EC_0 of 10 to 14 mmhos/cm) of the capillary zone reduced monthly and seasonal water use from the water tables as compared with the low salinity (EC_0 of 2 to 3 mmhos/cm) conditions. The high moisture treatment delayed significant use of water from 183- and 274- cm water tables until late in the season, when irrigations were discontinued and the upper soil profile dried.

68-69:02F-009
PERFORMANCE OF TILE DRAINS UNDER IRRIGATION IN SOUTHERN ALBERTA,
Rapp, E., and Laliberte, G. E.
Lethbridge, Alberta, Canada, Dept of Agriculture.
Canadian Agricultural Engineering, Vol. 10, No. 2, p 64-69, 1968. 2 tab, 6 fig, 11 ref.

Descriptors: *Irrigation, *Saline soils, *Saturated soils, *Drainage systems, *Tile drainage, Arid lands, Semiarid climates, Groundwater, Subsurface drainage, Drainage effects, Loam, Sands, Tiles, Irrigation engineering, Water table.
Identifiers: *Canada, Alberta.

In an arid environment where irrigation is necessary to agricultural production, tile drains are often used to prevent water logging and salinity or to reclaim soil that was originally saline. The proportion of water applied that must be handled by the drainage system will vary according to soil, water and climatic conditions. The study was conducted in southern Alberta to provide guidelines for designing irrigation drainage systems for that area. Five tile drain systems were tested in areas of sandy loam and loams over sand for a 12-year period. Two interceptor tile drain systems proved highly effective in removing excess water and salts. The performance of three relief tile drains was highly variable. Since salinity of the effluent from relief drains showed no decrease with time, they were judged doubtful for reclamation purposes although they did effectively remove excess water. If relief drains are to be used, the authors suggest that spacing should be no more than 700 to 800 feet to achieve greater effectiveness.

68-69:02F-010
PLASTIC ORIFICE INSERTS FOR SUBSURFACE IRRIGATION,
Whitney, L. F., and Lo, K. M.
Massachusetts University, Amherst, Dept of Agricultural Engineering.
American Society of Agricultural Engineers, Transactions, Vol. 12, No. 5, p 602-604, 607, September-October, 1969. 3 fig, 6 tab, 4 ref.

Descriptors: *Subsurface irrigation, *Irrigation design, *Plastics, *Orifices, *Pipes, Flow rates, Equipment, Irrigation systems, Nozzles, Orifice flow, Pipe flow, Porous media, Application methods, Costs, Design, On-site tests, Tubes, Water distribution (Applied).

Economies in water use, plus advantages of liquid fertilizer and herbicide injection, have made subsurface irrigation the object of much study. Research has shown that the major problem of using plastic pipe for underground irrigation networks lies in developing a discharge orifice that resists clogging from internal water impurities and external soil particles. Three orifice designs were investigated: porous media, in-wall orifices protected by labyrinths, and plastic insert orifices. Results of the study were disappointing for porous media and in-wall orifice designs, the latter being completely unreliable. A plastic insert orifice was designed which featured uniform water distribution, easy installation, and low manufacturing cost.

68-69:02F-011
AN APPLICATION OF SURFACE GEOPHYSICAL TECHNIQUES TO THE STUDY OF WATERSHED HYDROLOGY,
Shields, Ronald R., and Sopper, William E.
Geological Survey, Helena, Montana.
Water Resources Bulletin, Vol. 5, No. 3, p 37-49, September 1969. 6 fig, 2 tab, 16 ref.

Descriptors: *Hydrogeology, *Surveys, *Geophysics, *Seismic studies, *Electrical studies, Aquifers, Water table, Water management (Applied), Subsurface mapping, Small watersheds, Water storage, Springs, Streams.
Identifiers: Groundwater prospecting (Geophysical).

The applicability of geophysical methods to experimental watershed research is demonstrated by a study of a 106-acre forested watershed in central Pennsylvania. Data from a shallow seismic refraction study and an electrical resistivity study of the watershed were used to determine the depth of soils, their volumes, depth to bedrock, configuration of the bedrock surface and delineation of the bedrock surface and of the water table. With this information on the subsurface conditions, the hydrologic properties of the watershed were described in greater detail. This information is of value in explaining the watershed's response to various watershed treatment practices that eventually will be used.

68-69:02F-012
DETERMINING SPECIFIC YIELD OF THE OGALLALA AQUIFER BY THE NEUTRON METHOD,
Jones, Ordie R., and Schneider, Arland D.
Agricultural Research Service, Bushland, Texas.
Water Resources Research, Vol. 5, No. 6, p 1267-1272, December 1969. 5 fig, 2 tab, 10 ref.

Descriptors: *Specific yield, *Aquifers, *Alluvium, *Nuclear moisture meters, Texas, Instrumentation, Surveys, Radioactivity, Water levels, Water level fluctuations, Permeability.

Identifiers: Ogallala Formation, Neutron moisture meters, Pumping tests, Aquifer testing.

The specific yield of the Ogallala formation, a water table aquifer, was determined with a neutron moisture meter. An access tube penetrated a 12-foot section of the aquifer. This section was saturated by recharging water to the aquifer and then dewatered by pumping for 11 days. The specific yield of the aquifer was calculated from neutron moisture measurements made at saturation after most gravity drainage had occurred. The average specific yield for 25 measurements made at 1/2-foot intervals was 0.22. This value compares favorably with the specific yields determined by tracer techniques and laboratory analysis of cores. However, the specific yield determined by the neutron method was 50% greater than the specific yield determined by pumping tests.

68-69:02F-013
METHOD FOR COMPUTING GROUNDWATER LEVEL FLUCTUATIONS,
Vol'ftsun, I. V.
Translated from State Hydrologic Institute (Trudy GGI), No. 165, p 128-147, 1969.
Soviet Hydrology: Selected Papers, Issue No. 2, p 115-130, 1969. 7 fig, 4 tab, 2 ref, 3 append.

Descriptors: *Water level fluctuations, *Groundwater, *Water balance, *Hydrologic budget, Infiltration, Precipitation (Atmospheric), Recharge, Evapotranspiration, Discharge (Water), Groundwater movement, Water table, Surface-groundwater relationships.
Identifiers: Groundwater-level fluctuations.

A water balance method can be used to calculate groundwater-level fluctuations during the growing season. For coarse-texture soils and a groundwater depth of about 1.5 m, when the seepage time of precipitation through the aeration zone is 1 day or less, when there is no backwater from rivers or lakes, and no water exchange between aquifers, the method of computation described can be used to precalculate the groundwater level one day in advance. It can also be used to predict fluctuations of flow over a long period preceding a given data, from precipitation, air moisture deficit, and wind speed data. It is possible to determine the effect of human activity, such as for example, the planting of forests, various agricultural practices, etc., on groundwater level regime and surface runoff in the catchment.

68-69:02F-014
THE USE OF THE GEOELECTRIC METHOD FOR INVESTIGATING GEOLOGIC AND HYDROLOGIC CONDITIONS IN SANTA CLARA COUNTY, CALIFORNIA.
Page, Leo M.
Santa Clara Valley Water Conservation District, California.
Journal of Hydrology, Vol. 7, No. 2, p 167-177, January 1969. 8 fig, 1 tab, 5 ref.

Descriptors: *Electrical studies, *Resistivity, *Surveys, *Groundwater, Geophysics, Aquifers, Water table, Water levels, Water level fluctuations, Porosity, Permeability, Transmissivity, Water yield, Discharge (Water).
Identifiers: *Santa Clara County (Calif.).

The basic procedures used in electric resistivity exploration of geologic and hydrologic conditions in Santa Clara County, California are described. Typical examples of resistivity information checked against drilling and well testing are included. The advantages of the resistivity method are low cost, ease of operation, speed, accuracy, and ease of training operations. The initial cost of the equipment used was about $1,000 and the maintenance cost was about $100 per year. Since 1964, over 800 electric soundings to depth of 200-500 ft and over 10,000 shallow profiles were made. The Wenner and Schlumberger electrode configurations are used. The usual procedure is to run a grid of profiles to learn the general geological properties of an area and then to make several probes to learn the vertical extent of the major geohydrologic zones. Recent water level conditions in the county are mapped.

68-69:02F-015
TILE CLOGGING BY IRON AND MANGANESE IN IMPERIAL VALLEY, CALIFORNIA.
Grass, Luther B.
Agricultural Research Service, Brawley, California.
Journal of Soil Water Conservation, Vol. 24, No. 4, p 135-138, July-August 1969.
7 fig, 2 tab, 19 ref.

Descriptors: *Drain tiles, *Tile drains, *Iron oxides, Manganese compounds, Drainage, Drainage engineering, Drainage systems, Tiles, Tile drainage, Drains, Deposition, Chemical precipitation, Soil types, Operation and maintenance, Irrigation operation and maintenance, Bibliographies, Iron bacteria.
Identifiers: *Clogging, Imperial Valley (Calif.), Imperial Irrigation District (Calif.).

Tile drains are used extensively in the Imperial Valley of California to control water tables and prevent salt accumulation in soils. By 1955, water tables had developed over some tile lines, reducing crop growth either by restricting root growth or by increasing salinity. When opened for inspection, the lines were found clogged by black and red deposits composed of manganese and iron oxides. Theories proposed to explain the deposits are: (1) the problem predominates near faults, (2) the problem is peculiar to certain soil textures, and (3) the type of tile used contributes to the problem. A survey was made of tile lines in the Imperial Valley. The severity of clogging varied widely and the deposits were observed in various physical forms. The survey indicated that formation of red or black deposits was not related to location, soil type, kind of tile material, or length of time the drains had been in service. Tile systems clogged with iron and manganese deposits can be reclaimed effectively by treatment with sulfur dioxide gas and water.

68-69:02F-016
DRAIN INSTALLATION FOR NITRATE REDUCTION,
Willardson, L. S., Meek, B. D., Grass, L. B., Dickey, G. L., and Bailey, J. W.
Agricultural Research Service, Brawley, California.
Groundwater, Vol. 8, No. 4, p 11-13, July-August 1970. 2 fig, 2 tab, 2 ref.

Descriptors: *Denitrification, *Biodegradation, *Nitrates, *Groundwater, *Drainage systems, Subsurface drainage, Drawdown, Water level fluctuations, Saturated flow, Unsaturated flow, Aeration.
Identifiers: Groundwater denitrification.

A field experiment was installed near Firebaugh in the San Joaquin Valley of California to test submerged drains as a means of denitrification of groundwater. Laboratory and field experiments show that denitrification occurs in saturated soil where there is ample organic carbon available for bacterial metabolism. Denitrification and dilution of high nitrate groundwater were accomplished in the field study.

68-69:02F-017
GROUNDWATER MOVEMENT TOWARD ARTIFICIAL CUTS,
Kashef, Abdel-Aziz I.
North Carolina State University, Raleigh.
Water Resources Research, Vol. 5, No. 5, p 1032-1040, October 1969. 3 fig, 2 tab, 11 ref.

Descriptors: *Groundwater movement, *Saturated flow, *Steady flow, *Excavation, Drainage, Water table, Water levels, Aquifers, Hydraulic conductivity, Aquicludes, Seepage, Inflow.
Identifiers: Drainage to excavations.

Artificial cuts, such as open channels and highway cuts, produce an imbalance in the original groundwater system. The developed drawdowns due to these cuts under the condition of saturated steady flow are studied theoretically by analyzing the seepage through trapezoidal sections of earth entailing the complexity of the free surface. The procedure is then extended to actual cases of extensive aquifers where such cuts exist. The proposed method is compared with some of the available rigorous mathematical solutions, such as those given by Falkovich, Mikhailov, Meletchenko, Pavlovsky, and Polubarinova-Kochina. The proposed method is simpler in its application and also gives a complete solution for the free surface, the discharge face, the rate of flow, and the hydropotential distribution within the affected region, whereas the rigorous methods are planned essentially for the solution of the free surface only.

68-69:02F-018
PERMEABILITY OF ORTHOTROPIC POROUS MEDIUMS,
Szabo, Barna A.
State University of New York, Buffalo.
Water Resources Research, Vol. 4, No. 4, p 801-808, August 1968. 4 fig, 1 tab, 13 ref.

Descriptors: *Porous media, *Mohr circle, *Permeability, Darcy's Law, Groundwater, Hydraulics, Mathematical studies.
Identifiers: Transformation law, Orthotropic, Porous mediums.

A mathematical definition of permeability is developed from the assumption that orthotropic porous mediums obey Darcy's Law in the three directions normal to the structural planes of symmetry of the medium. This assumption leads to the conclusion that permeability obeys the transformation law definitive of second-order tensors; and that consequently a permeability quadric (the Mohr circle representation of transformation of permeability components and permeability invariants) can be defined. It was concluded that permeability, because of its transformation properties, is analogous to these conceptually unrelated physical objects. This analogy permitted the application of the Mohr circle to represent the transformation of permeability components in any principal plane.

68-69:02F-019
NUMERIC STUDIES OF A COMPOSITE SOIL MOISTURE GROUNDWATER SYSTEM,
Hornberger, G. M., Remson, Irwin, and Fungaroli, A. A.
Drexel Institute of Technology, Philadelphia, Pa.
Water Resources Research, Vol. 5, No. 4, p 797-802, August 1969. 5 fig, 1 tab, 7 ref.

Descriptors: *Groundwater movement, *Soil water movement, *Mathematical models, Model studies, Infiltration, Percolation, Water table, Darcy's Law, Dupuit-Forchheimer theory.
Identifiers: Soil water-groundwater relations.

A model of transient moisture movement in a composite soil moisture-groundwater system is described. The model was used to study two-dimensional flow in response to a falling water table. The solution provided information about the interaction of the saturated and unsaturated portions of the subsurface system. The results of the composite model are compared with those obtained from three one-dimensional groundwater models. That soil moisture and nonlinearity do not have a significant effect on the position of the water table in the system studied is inferred.

68-69:02F-020
SIMILARITY APPROXIMATION FOR THE RADIAL SUBSURFACE FLOW PROBLEM,
Drake, R. L., Molz, F. J., Remson, Irwin, and Fungaroli, A. A.
Drexel Institute of Technology, Philadelphia, Pa.
Water Resources Research, Vol. 5, No. 3, p 673-684, June 1969. 3 fig, 1 tab, 12 ref.

Descriptors: *Mathematical models, *Mathematical studies, *Approximation method, *Groundwater movement, Flow, Porous media, Saturated flow, Unsaturated flow, Synthetic hydrology, Simulation analysis, Computer programs, Digital computers.
Identifiers: *Similarity approximation, Radial groundwater flow.

A useful mathematical technique in the study of radial flow of underground water is the application of similarity transformations, such as Boltzmann's transformation. The transformations lead to approximations that are shown to be valid if certain physical parameters satisfy given limiting conditions. A nonlinear partial differential equation is formulated describing the radial flow of soil moisture. A similarity approximation is used to transform the partial differential equation into a nonlinear ordinary differential equation. Criteria by which to judge the applicability of the similarity approximation are derived. Several monotonicity properties of the transformed moisture as a function of the similarity variable are derived. The properties are used to develop numeric procedure for the solution of the transformed equation. The procedure is used to study the radial flow of soil moisture to a cylindric sink for diffusivities which vary linearly, quadratically, and exponentially with soil moisture. The solutions show that the moisture front steepens with increasing nonlinearity.

68-69:02F-021

UNSTEADY SEEPAGE FLOW BETWEEN FULLY-PENETRATING TRENCHES,

Karadi, Gabor, Krizek, Raymond J., and Elnagger, Hameed
Wisconsin University, Milwaukee, Dept of Mechanics.
Journal of Hydrology, Vol. 6, No. 4, p 417-430, August 1968. 9 fig, 3 ref.

Descriptors: *Unsteady flow, *Groundwater movement, *Drainage effects, *Ditches, Dupuit-Forchheimer theory, Digital computers.
Identifiers: Matrix computation methods.

Unsteady seepage flow between 2 fully penetrating trenches is analyzed for homogeneous isotropic porous media characteristics. The solution may be extended to a cross-anisotropic porous medium. The method uses matrix mathematics to solve a nonlinearized equation derived from Dupuit-Forchheimer approximations and the replacement of partial differential equations with a system of ordinary differential difference equations. The method may easily be adopted to computers and handles complicated boundary and initial conditions as well as allowing step by step treatment of the non-linearity of the differential equation. The results calculated are in better agreement with experimental results than are results obtained by the use of linearized field equations.

68-69:02F-022

PERMEABILITY CALCULATED FROM DESATURATION DATA,

Laliberte, Garland E., Brooks, Royal H., and Corey, Arthur T.
Canada Dept of Agriculture, Lethbridge, Alberta.
ASCE Proceedings, Journal of the Irrigation and Drainage Div., Vol. 94, No. IR1, Paper No. 5843, p 57-71, March 1968. 3 fig, 3 tab, 23 ref, 2 append.

Descriptors: *Permeability, *Porous media, *Soils, *Pore pressure, Drainage, Model studies, Equations, Soil compaction, Saturation, Regression analysis.
Identifiers: Capillary pressure-permeability relationships, Porosity-permeability relationships, Kozeny equations.

An equation is presented for calculating saturated permeability from capillary pressure-desaturation data. The use of this equation along with the relative permeability equations of Brooks and Corey is proposed for calculating the permeability of both saturated and partially saturated media. The analysis leading to the development of the equation is based on theory developed in the petroleum industry. The equation utilizes parameters introduced by Brooks and Corey for describing the hydraulic behavior of partially saturated porous media on the drainage cycle. In laboratory measurements, the permeability of three disturbed soils each packed at 5 different values of porosity was determined at various capillary pressures. Predicted relationships were calculated using capillary pressure-desaturation data in the new equation and in the relative permeability equations of Brooks and Corey. Calculated and experimental values of permeability agreed within 27% over the range of capillary pressures studied.

68-69:02F-023

LABORATORY EVALUATION OF SELECTED RADIOISOTOPES AS GROUND-WATER TRACERS,

Jennings, A. Ray, and Schroeder, Melvin C.
Texas A&M University, College Station.
Water Resources Research, Vol. 4, No. 4, p 829-838, August 1968. 2 fig, 3 tab, 16 ref.

Descriptors: *Tracers, *Radioisotopes, *Ground-water movement, Velocity distribution pattern, *Ion exchange, Adsorption.
Identifiers: *Groundwater tracers, Radioactivity.

Tracer appearance results from movement along the most direct flow path, and thus arrival of the maximum concentration is the best index for determining average water velocity. Antimony 121, cerium 141. chromium 51, indium 114, ruthenium 103, and strontium 85 in chelate form were tested, as the unchelated ions are subject to greater decay by adsorption and ion exchange. Distribution-coefficient measurements were made under static conditions for crushed illitic shale and limestone. These measurements can be used to predict the elution history of a tracer from an exchange column. Comparisons of the predictions, the tracer elution histories, and elution histories for chloride pulses indicate that chelated chromium 51 is an adequate groundwater tracer. Average velocity of groundwater is equal to the sum of the tracer velocity plus the product of the tracer velocity, the distribution coefficient, and the bulk density of the aquifer divided by its effective porosity. The distribution coefficient for an ideal tracer is zero; the average velocity of this tracer is equal to the average groundwater velocity.

68-69:02F-024
TWO-DIMENSIONAL SEEPAGE OF BONDED WATER TO FULL DITCH DRAINS,
Warrick, A. W., and Kirkham, Don.
Iowa State University, Ames, Dept of Agronomy.
Water Resources Research, Vol. 5, No. 3, p 685-693, June 1969. 4 fig, 8 ref.

Descriptors: *Drainage systems, *Ditches, *Seepage, *Mathematical models, Synthetic hydrology, Drainage engineering, Dewatering, Hydraulic conductivity, Anisotropy, Soils, Soil water movement, Groundwater movement.
Identifiers: Nomogram.

Seepage of ponded water to full, equally spaced ditch drains is analyzed mathematically, considering 4 distinct cases. In the first case, an impermeable soil barrier is present at a finite depth, and the ditches are a finite distance apart; in the second case, no impermeable soil barrier is present, and the ditches are a finite distance apart; in the third case, an impermeable barrier is present, but the ditches are in effect an infinite distance apart; and in the fourth case, no impermeable barrier is present, and the ditches are in effect an infinite distance apart. The ditches may penetrate part or all of the way to an impermeable barrier. Schwartz-Christoffel transformations are used to solve the first case. Solutions for the other 3 cases are found by taking limiting values of the first case. Flow nets illustrate the results. In one calculated example, the flow rate without an impermeable barrier is 10% greater than when an impermeable barrier exists at a depth of 0.2 times the ditch semispacing. The flow nets illustrate the rapid decrease in surface water intake at increasing distances from the ditch. A nomogram gives seepage rates when no impermeable barrier is present and infinitely wide spacing is used. An illustration shows that the nomograph is useful to estimate seepage rates for flow media of finite depth and width.

68-69:02F-025
ROOTZONE SALT PROFILES AND ALFALFA GROWTH AS INFLUENCED BY IRRIGATION WATER SALINITY AND LEACHING FRACTION,
Bower, C. A., Ogata, G., and Tucker, J. M.
Agricultural Research Service, Riverside, Calif.
Agronomy Journal, Vol. 61, No. 5, p 783-785, September-October 1969. 1 tab, 3 fig, 2 ref.

Descriptors: *Arid lands, *Irrigation water, *Drainage water, *Saline water, *Plant growth, Saline soils, Lysimeters, Alfalfa, California, Root zone, Soil-water-plant relationships.

Alfalfa was grown in 24 lysimeters at Riverside, California, with 12 irrigation water salinity and leaching fraction treatments. Plant yield was related to the salinity that developed in the root zone. The first increments of leaching were most effective in preventing salt accumulation in the soil. At high leaching fractions, much of the water applied beyond that required for evapotranspiration was of little effect in lowering soil salinity.

68-69:02F-026
THE INFILTRATION COMPONENT OF A PASTORAL EXPERIMENTAL CATCHMENT, PARTS 1 AND 2,
Dunin, F. X.
Soil Conservation Authority, Kew, Australia.
Journal of Hydrology, Vol. 7, No. 2, p 121-146, January 1969. 8 fig, 6 tab, 13 ref.

Descriptors: *Surface-groundwater relationships. *Hydrograph analysis, Rainfall-runoff relationships, Rainfall disposition, Infiltration, Recharge, Streamflow, Runoff, Bank storage, Base flow, Water storage, Antecedent precipitation, Demonstration watersheds, Model studies, Water management (Applied).
Identifiers: *Australia, Parwan Experimental Area, Antecedent soil moisture.

A method of hydrographic analysis is proposed for the determination of the average infiltration rate during specified intervals of a surface runoff event. This method uses the continuity equation to follow the disposition of the rainfall during the selected hydrograph intervals, using a measure of the surface detention relations for the catchment under study. The variation of the infiltration rate during the runoff event under analysis was expressed as an inverse exponential relationship between infiltration rate and accumulated soil moisture. Description of infiltration characteristics in this form facilitates the assessment of hydrologic effects of changed land-use. Infiltration characteristics of a series of runoff events were compared as a measure of the efficacy of hydrographic analysis and also to provide a mathematical description of the infiltration component of the experimental catchment. This involved the estimation of soil moisture antecedent to runoff production by an indirect method based on the simulation of runoff production. The comparison demonstrated that infiltration characteristics were consistent with either of two relationships derived from hydrographic analysis. The variation of the infiltration performance between these two sets of infiltration characteristics was shown to be seasonal and was attributed to swelling of the colloid fraction of the soil.

68-69:02F-027
HYDRODYNAMIC DISPERSION IN A SATURATED HOMOGENEOUS POROUS MEDIUM AT LOW PECLET NUMBERS AND NON-HOMOGENEOUS SOLUTION,
Bachmat, Yehuda.
Guelph University, Ontario, Canada.
Water Resources Research, Vol. 5, No. 1, p 139-143, February 1969. 7 ref.

Descriptors: *Dispersion, *Diffusion, *Porous media, Flow, Groundwater movement, Density, Circulation, Fluid mechanics, Mass transfer, Mixing.
Identifiers: Binary solutions, Density gradient.

The coefficient of mechanical dispersion of a solute in a homogeneous porous medium saturated by a binary diluted solution is derived, taking into account nonuniform density and viscosity fields. It is shown that in the neighborhood of a vanishing macroscopic velocity, a nonuniform density field induces a macroscopic dispersion resulting from the variation of microscopic density gradients and from horizontal variations of the macroscopic density. Both together yield the macroscopic effect of density instability on solute redistribution phenomena in porous materials.

68-69:02F-028
THE USE OF GRAVITY SHAFTS FOR GROUNDWATER RECHARGE - PHASE I,
d'Errico, T. R., and Skodje, M. T.
North Dakota Water Resources Research Inst., Fargo.
Research Project Technical Completion Report, Water Resources Research Inst. WI-222-002-70, January 1970. 22 p, 2 tab, 8 fig.

Descriptors: Laboratory tests, Permeability, Turbidity, *Sedimentation, *Shafts (Excavations), Groundwater recharge, North Dakota.
Identifiers: Sheyenne River North Dakota), *Gravity recharge, Sand-filled shafts, Clogging patterns, Air-binding.

The hydraulic characteristics of shafts consisting of uniformly graded sand were studied in the laboratory to predict their applicability for the recharge of glacially deposited aquifers overlain with impervious soils. Water containing various levels of turbidity was applied to shafts consisting of three different sizes of sand. Piezometers were used to measure the head-loss gradients. At the completion of each test, the amount of sediment trapped in the different levels of the shaft was determined. Permeabilities of the three sand sizes using clear tap water were observed to be 14,400, 4,500, and 3,400 GPD per square foot. No 'airbinding' of the shafts was noted, and the clogging of the shafts was limited to the upper three inches of the shaft. Below this layer the permeability remained constant. Field tests should be conducted to determine whether periodic restoration of the upper level of the shaft is more economical and practical than shaft abandonment and replacement. Two different shaft designs are proposed for use with these two methods of operation. The permeability of the shaft is decreased more rapidly when higher turbidities are applied. Sedimentation of the Sheyenne River water as a method of reducing the sediment loading does not appear practical except during high river stages when turbidities exceed 100 mg per liter.

68-69:02F-029
GROUNDWATER STUDIES IN THE SABI VALLEY, RHODESIA, USING NATURAL TRITIUM MEASUREMENTS,
Wurzel, P., and Ward, P. R. B.
Agricultural Research Council of Central Africa.
Journal of Hydrology, Vol. 8, No. 1, p 48-58, May 1969. 2 fig, 1 tab, 10 ref.

Descriptors: *Groundwater movement, *Tracers, *Tritium, Base flow, Laboratory tests, Electrolysis, Radio-chemical analysis, Surface-groundwater relationships.
Identifiers: *Sabi Valley (Rhodesia).

Environmental tritium was used as a groundwater tracer in the Sabi Valley Alluvial plain in Rhodesia, and flow data was obtained on a regional scale. It is shown that its groundwater movement is closely approximated by direct flow and the tritium content in boreholes is related to tritium input in 2 areas of recharge. The preliminary results indicate that the Sabi River is playing a greater part in the groundwater regime of the alluvial plain than originally anticipated. Velocity of movement of the groundwater is deduced as 2-5ft/day. The low level tritium counting system used in the authors' laboratory is briefly described, and the limit and accuracy of measurement is discussed.

68-69:02F-030
THE MECHANISM OF NATURAL GROUNDWATER RECHARGE AND DISCHARGE-1. ONE-DIMENSIONAL, VERTICAL, UNSTEADY, UNSATURATED FLOW ABOVE A RECHARGING OR DISCHARGING GROUND-WATER FLOW SYSTEM,
Freeze, R. Allan.
Dept of Energy, Mines and Resources, Calgary, Alberta, Canada.
Water Resources Research, Vol. 5, No. 1, p 153-171, February 1969. 9 fig, 2 tab, 33 ref.

Descriptors: *Unsteady flow, *Saturated flow, *Unsaturated flow, *Infiltration, Mathematical models, Evaporation, Water-level fluctuations, Percolation, Recharge, Discharge (Water), Darcy's Law, Soil water movement, Groundwater movement, Rainfall intensity.
Identifiers: Transient flow.

The unsaturated flow processes of infiltration and evaporation are in physical and mathematical continuity with the parallel saturated processes of recharge and discharge. Water table fluctuations result when the rate of groundwater recharge or discharge is not matched by the unsaturated flow rate created by infiltration or evaporation. A water table rise provides the source of replenishment to the groundwater zone that allows the prevailing rate of recharge to continue. This dynamic water table behavior can be simulated by a one-dimensional, numerical mathematical model involving transient flow through an integrated saturated - unsaturated system. The solutions are applicable to homogeneous, isotropic soils in which the functional relationships show hysteresis properties. The model allows upper boundary conditions of constant rate rainfall, ponded water, evaporation, and redistribution. It can be used to determine the water table fluctuation that will arise from a given set of initial conditions, boundary conditions, and soil type. The effects of variations in the parameters that control the flow are examined to arrive at a better understanding of the mechanism of natural groundwater recharge and discharge.

68-69:02F-031
DETERMINING THE RATIO OF HORIZONTAL TO VERTICAL PERMEABILITY BY AQUIFER-TEST ANALYSIS,
Weeks, Edwin P.
Geological Survey, Madison, Wis.
Water Resources Research, Vol. 5, No. 1, p 196-214, February 1969. 6 fig, 1 tab, 22 ref.

Descriptors: *Groundwater movement, *Permeability, Anisotropy, Aquifers, Beds, Unsteady flow, Porosity, Interstices, Piezometers, Piezometry, Theis equation, Drawdown, Water level fluctuations.
Identifiers: Aquifer anisotropy, Vertical permeability, Horizontal permeability, Aquifer testing, Pumping tests, Partially penetrating wells.

The ratio of horizontal to vertical permeability may be determined by analysis of drawdown data from piezometers or partially penetrating observation wells near a partially penetrating production well. The analyses are made by comparing measured drawdowns in the piezometers to those predicted if the production well fully penetrated the aquifer. The differences between the measured and predicted drawdowns are determined, and the distances from the pumped well at which these differences would occur in an isotropic aquifer are determined from an equation. The permeability ratio is computed as the square of the ratio of actual distances to computed distances. The ratio of horizontal to vertical permeability in glacial outwash in central Wisconsin was determined from 5 aquifer tests to range from about 2 to about 20.

68-69:02F-032
IDENTIFICATION OF NONLINEAR PARAMETERS OF GROUNDWATER BASINS BY HYBRID COMPUTATION,
Vemuri, Venkateswararao, and Karplus, Walter J.
California University, Los Angeles.
Water Resources Research, Vol. 5, No. 1, p 172-185, February 1969. 8 fig, 13 ref.

Descriptors: *Groundwater basins, *Aquifers, *Computer models, *Parametric hydrology, *Water table, Analog computers, Digital computers, Data processing, Equations, Hydrologic data, Transmissivity, Input-output analysis, Systems analysis, Boundaries (Surfaces), California, Contours, Storage coefficient, Mathematical models.
Identifiers: *Parameters, *Hybrid computers, Algorithms, San Fernando Valley, California.

Identification of parameters of an unconfined aquifer in which the dynamics of the water table were describable by a partial differential equation can be looked upon as a control system problem in distributed parameters systems. A maximum principle was used in conjunction with a steepest descent algorithm and the transmissibility of an aquifer was identified starting from observed values of input-output as data. This algorithmic procedure was blended with a heuristic method to identify the storage coefficient and the boundary of an aquifer in the San Fernando Valley basin in the city of Los Angeles. Some typical results of computations carried out on the hybrid computer were presented. This work demonstrates the computational advantages in combining analog and digital hardware, not only in terms of the gain in computational time but also in terms of the flexibility offered by the system.

68-69:02F-033
DRAINING AREA UNDERLAIN BY HIGHLY PERMEABLE SHALLOW SAND AQUIFER,
Allen, R. R., and Myers, V. I.
Agricultural Research Service, Washington, D.C.
Transactions of ASAE, Vol. 12, No. 1, p 29-31, January 1969. 6 fig, 5 ref.

Descriptors: *Aquifers, *Drainage systems, *Drains, *Tiles, *Subsurface drainage, Permeability, Sands, Texas, Electrical resistance, Electrical conductance, Analog models, Model studies, Water table, Flow measurement, On-site data collections, Effluents, Soil water movements.

This paper reports a field and electrical resistance analog study of subsurface tile drainage of an area near Raymondville, Texas, where the top of the sand aquifer was 10 ft. below ground surface. A subsurface tile drain, placed 8 ft. deep, yielded considerable effluent yet had a limited effect on the water table. Field and electrical analog data indicated that the underlying aquifer supplied 70 to 75% of the total tile flow. It was suggested that successful water table control might be achieved.

68-69:02F-034
POINT DILUTION METHODS OF INVESTIGATING GROUND WATER FLOW BY MEANS OF RADIOISOTOPES,
Drost, Walter, Klotz, Dietmar, and Koch, Arnd.
Institut fur Radiohydrometrie, Munich, Federal Republic of Germany.
Water Resources Research, Vol. 4, No. 1, p 125-146, February 1968. 15 fig, 3 tab, 30 ref.

Descriptors: *Tracers, *Radioactive isotopes, Dyes, Groundwater, *Wells, Dams, Permeability, Piezometers, Porous materials, Model tests, Underseepage, Field tests, Seepage, Bibliographies, *Groundwater flow.
Identifiers: Radiation detectors, Gold isotopes, Foregin testing, West Germany, *Dilution method, *Water wells.

The distortion of the flow field by a well must be known to apply the point dilution method of measuring groundwater flow by tracers. The distortion can be calculated if aquifer permeability is less than or equal to gravel pack permeability, and if gravel pack permeability is less than or equal to well screen permeability. The tracer must be adequately mixed during the dilution procedure. Experiences obtained from model tests are applied to field investigations. Peak-to-peak and total count methods were used in wells having a vertical flow to determine depths and rates at inflow and outflow. The direction of groundwater flow was determined by the point dilution method; a radioactive tracer is injected into the well screen water column and measured by a collimated probe that is sensitive to the direction of incident radiation. Using tracers that are fixed on the soil is advisable; Gold 198 is the most suitable tracer. Strong, vertical currents in a well present a serious obstacle to field measurements of the rate and direction of groundwater flow.

68-69:02F-035
DRAWDOWNS DUE TO PUMPING FROM STRIP AQUIFERS,
Bokhari, S. M. H., Strachan, J. K., and Turner, A. K.
Irrigation & Power Dept, Govt. of West Pakistan, Lahore.
Journal of the Irrigation & Drainage Div, ASCE, Vol. 94, No. IR2, Proc. Paper 5981, p 233-242, June 1968. 4 fig, 1 tab, 7 ref.

Descriptors: Drawdown, *Groundwater, *Pumping, Strip aquifer, Water resources, *Wells.

Drawdown patterns due to pumping from wells in long narrow (strip) aquifers are dependent mainly on the type of side boundary (recharge, impermeable). A theoretical solution is developed for an idealized confined aquifer with impermeable boundaries, and the results compare favorably with those obtained from complementary tests using a membrane analog. Solutions are also given for the simpler case of recharge boundaries. Either the mathematical or membrane solutions should be suitable for field purposes, including certain conditions of unconfined flow.

68-69:02F-036
CONJUNCTIVE USE OF GROUND AND SURFACE WATERS,
Doody, James J.
California State Dept of Water Resources, Los Angeles.
Journal of American Water Works Assn., Vol. 61, No. 8, p 395-397, August 1969.

Descriptors: *Conjunctive use, *Model studies, *Mathematical models, *Groundwater basins, *California, Optimization, Economics, Computer models, Digital computers, Water management (Applied), Water resources development, Surface waters.
Identifiers: Groundwater basin models.

Partial or total application of the methods will provide much of the data necessary for making current management decisions as to the best way of meeting future water demands. Not only can a few arbitrarily selected operational plans be compared by its use, but the tools are also provided whereby an optimum plan can be derived by the local water agency. The economic impact of various legal and political constraints on the optimum plan can also be evaluated. Because this method is written in general terms and preserved in computer programs, it permits rapid updating and adjustment of operating criteria as conditions change, as more geologic and hydrologic information becomes available, and as experience is gained in actual operations.

68-69:02F-037
LAND SUBSIDENCE ALONG THE DELTA-MENDOTA CANAL, CALIFORNIA,
Prokopovich, N. P., and Herbert, D. J.
Bureau of Reclamation, Sacramento, California.
American Water Works Assn., Vol. 60, No. 8, p 915-920, August 1968. 11 fig.

Descriptors: *Subsidence, *Overdraft, *California, *Canals, Drawdown, Water levels, Irrigation water, Damages, Flooding, Submergence.
Identifiers: Delta-Mendota Canal (Calif.).

Land subsidence caused by groundwater overdraft is changing the gradient of the Delta-Mendota Canal, California. Bridges are submerged and the canal lining is 1-6 ft. lower than when it was installed in some locations. Replacement of well water by canal water for irrigation has ended the overdraft, but continued lag subsidence may be expected to amount to as much as 2 ft. in the next 25 years.

68-69:02F-038
THE INVESTIGATION OF WATER FLOW THROUGH POROUS MEDIUMS BY MEANS OF RADIOTRACERS,
Ellis, W. R., Kevi, L., and Wiebenga, W. A.
Australian Atomic Energy Commission Research Establishment, Lucas Heights, N.S.W.
Water Resources Research, Vol. 4, No. 2, p 413-416, April 1968. 2 fig, 1 tab, 6 ref.

Descriptors: *Groundwater movement, *Dispersion, *Tracers, Hydraulic models, Porosity, Porous media, Sands, Dupuit-Forchheimer theory.
Identifiers: Bromine radioisotopes.

The radioisotope bromine 82 was used to measure the flow of water through a packed sand column. It was shown that the commonly accepted Dupuit-Forchheimer assumption did not apply under these conditions. Some information was also obtained on lateral dispersion using iron gauzes and copper 64 solution.

68-69:02F-039
CONCEPTS IN GROUND WATER MANAGEMENT,
Mann, John F., Jr.
Journal of American Water Works Assn., Vol. 60, No. 12, p 1336-1344, December 1968. 22 ref.

Descriptors: *Groundwater, Groundwater mining, Water quality, Thermal pollution, Aquifers, Groundwater flow, Groundwater movement, Groundwater basins, Groundwater recharge, Salinity, Water reuse, Filtration, Quality control, Waste water treatment, Turbidity, Temperature control, Waste water disposal, Water table, Bibliographies, Safe yield.
Identifiers: *Groundwater management, Artificial replenishment, Groundwater hydrology.

The goals of groundwater management are part of a general objective of serving present and future demands for water at minimum cost and acceptable quality. The goals should be coldly practical, recognizing that almost every use of water results in some biological, chemical, or thermal deterioration. In most basins, the goal is continued usability. The trend is toward better control of the amounts and patterns of extractions, augmenting recharge to ground storage, decreasing evapotranspirative waste or outflows that go to waste, controlling mineral and thermal pollution, intensifying use of groundwater storage, and avoiding damage caused by high water tables or land-surface subsidence. Management objectives are aided by powerful computer techniques (developed mainly within the last 10 years) that predict and test the effects of many assumptions on the groundwater body.

68-69:02F-040
TRANSIENT FUNCTIONS FOR LAND DRAINAGE,
Jenab, S. A., Bishop, A. A., and Peterson, Dean F.
Utah State University, Logan, Dept of Agricultural and Irrigation Engineering.
ASCE Proc., Journal of Irrigation & Drainage Div., Vol. 95, No. IR3, Pap 6768, p 361-373, September 1969. 9 fig, 3 tab, 8 ref, append.

Descriptors: *Drainage, *Runoff, *Infiltration, *Overland flow, *Mathematical studies, Drainage effects, Drainage engineering, Drawdown, Diffusion, Transmissivity, Water storage, Recession curves, Discharge (Water).
Identifiers: Land drainage.

Solution of the diffusion equation for a line sink in a plane yields the error function. By superposition and integration, functions which describe the transient position and rate of fall of a water table under artificial drainage are developed for multiple drains. These may be used to determine in situ values of transmissivity and storage as well as for discharge. A means of using the method for any initial water table position is presented and some design examples are given.

68-69:02F-041
UNCONFINED AQUIFER CHARACTERISTICS AND WELL FLOW,
Esmaili, Houshang, and Scott, Verne H.
Engineering Science, Inc., Oakland, California.
American Society of Civil Engineers Proceedings, Journal of the Irrigation and Drainage Division, Vol. 94, No. IR1, Paper No. 5872, p 115-136, March 1968. 6 fig, 3 tab, 25 ref.

Descriptors: *Groundwater movement, *Unsteady flow, *Aquifer characteristics, Hydraulic conductivity, Storage coefficient, Darcy's law, Dupuit-Forchheimer theory, Injection wells, Withdrawal.
Identifiers: Unsteady radial flow.

Numerical solutions are developed for determination of aquifer characteristics and unsteady radial flow through injection wells in unconfined aquifers under constant drawdown and injection pressure conditions. These solutions are based on a numerical solution of the basic differential equation of flow. Appropriate dimensionless parameters are introduced to transform the basic differential equation of flow into an explicit form. Dimensionless graphical solutions are presented for the rate and accumulative volume of discharge and recharge and the radius of expansion of recharge mounds versus time for a range of drawdown and injection pressure values. Numerical examples are presented by applying these solutions to hypothetical field conditions.

68-69:02F-042
AN AQUIFER TEST USED TO INVESTIGATE A QUALITY OF WATER ANOMALY,
Jorgensen, Donald G.
Geological Survey, Huron, South Dakota.
Ground Water, Vol. 6, No. 6, p 18-20, November-December 1968. 4 fig, 1 tab, 5 ref.

Descriptors: *Water quality, *Groundwater, Aquifers, Artesian wells, South Dakota, Leakage.
Identifiers: Aquifer tests, Avon (South Dakota).

An aquifer test and analyses of water samples showed that the anomalous quality of water in a municipal well in Avon, South Dakota was caused by leakage from a nearby abandoned well tapping another aquifer. The test used the city well and 1 observation well. Analysis of test data indicated a transmissibility of 450gpd per ft before the cone of influence reached the recharge boundary and 1700gpd per ft after reaching it. A graphical method located an image well in about the same area as a 50-yr-old capped city well. The abandoned well was finished in the Dakota aquifer, which has a higher potentiometric surface than the Codell aquifer, in which the city well is finished. Leakage of the casing of the old well is further indicated by chemical quality of the water, which has about the composition and temperature of a mixture of Codell and Dakota water.

68-69:02F-043
LATERAL MOVEMENT OF WATER THROUGH THE UNSATURATED ZONE OF AN UNCONFINED AQUIFER,
Mobasheri, Fereidoun, Shahbazi, M., and Todd, D. K.
California University, Los Angeles, School of Engineering and Applied Science.
California University Water Resources Center Contribution No. 106, November 1965.
39 p, 10 fig, 3 tab, 12 ref, 2 append.

Descriptors: *Unsaturated flow, *Aquifers, *Groundwater movement, *Model studies, *Hydraulic models, Permeability, Water table, Analytical techniques, Interfaces, Hydraulic conductivity, Moisture tension.
Identifiers: Lateral unsaturated flow.

Unsaturated lateral flow in unconfined aquifers was studied by mathematical analysis, sand-box, and sand-column model studies. The hydraulic conductivity decreased as the negative pressure of the porous media increased. The calculated equivalent depth of the unsaturated zone for the sand used in the investigation was 35 cm. The flow rate through unsaturated zone increased with a decreasing rate as the unsaturated zone depth increased while the hydraulic gradient was kept constant. The rate of lateral flow movement could also be calculated to a reasonable accuracy from flow net diagrams or the graphical integration of the area under a characteristic conductivity curve. An example of the application of the results can be shown by the determination of underflow at Cedar Springs Damsite in Southern California where flow through unsaturated zone was neglected although the average depth of the aquifer was only

12 ft. The material is predominantly medium-grained sand with lenses of gravel and cobbles. As the average depth of the aquifer is 12 ft, the lateral flow through the unsaturated zone could amount to 11% of the total lateral flow.

68-69:02F-044

GEOCHEMICAL TRACING OF MINERAL WATER SOURCES IN THE SOUTH WESTERN DEAD SEA BASIN, ISRAEL,

Mazor, E., Rosenthal, E., and Ekstein, J.
Weizmann Institute of Science, Rehovoth (Israel).
Journal of Hydrology, Vol. 7, No. 3, p 246-275, March 1969. 8 fig, 3 tab, 21 ref, 2 append.

Descriptors: *Geochemistry, *Chemical analysis, *Water chemistry, *Mineral water, *Hydrogeology, Sampling, Water quality, Dossolved solids, Aquifer characteristics, Water temperature, Wells, Springs, Thermal water, Fresh water, Saline water, Salts, Lake basins, Trace elements, Radioactivity.
Identifers: *Israel, Dead Sea Basin.

Chemical composition of thermal and mineral waters along the southwestern shores of the Dead Sea was investigated. Data included 108 chemical analyses of different water samples, taken from 36 wells and springs. Chemical composition of the waters was used as a tracing tool for the determination of various groups of waters in the investigated area. Three distinct water groups were found in the area. The Kikar-Noit group waters had temperatures ranging up to 42 deg C and contained up to 17g/l dissolved solids. The Zohar-Yesha group waters had temperatures of 33 deg C to 39 deg C, 50-190g/l dissolved solids, and up to 40 mg/l H sub 2 S. The third group consisted of fresh waters. This report deals with the geographical extension of the established water groups and the mutual relations between them.

68-69:02F-045

ANALOG-DIGITAL MODELS OF STREAM-AQUIFER SYSTEMS

Moulder, E. A., and Jenkins, C. T.
Geological Survey, Denver, Colorado.
Ground Water, Vol. 7, No. 5 p 19-24, September-October 1969. 8 fig, 3 ref.

Descriptors: *Computer models, *Analog models, *Digital computers, *Surface-groundwater relationships, Conjunctive use, Model studies, Simulation analysis, Optimization, Water management (Applied), Streams, Aquifers, Water demand, Water rights.
Identifiers: Hybrid computer models.

The best features of analog and digital computers were combined to make a management model of a stream-aquifer system. The analog model provides a means for synthesizing verifying, and summarizing aquifer properties; the digital model permits rapid calculation of the effects of water-management practices. Given specific management alternatives, a digital program can be written that will optimize operation plans of stream-aquifer systems. The techniques are demonstrated by application to a study of the Arkansas River Valley in southeastern Colorado.

68-69:02F-046

CHEMICAL CHANGES IN TILE-DRAIN FILTERS AND DITCH BANKS CAUSED BY ANAEROBIOSIS,

Ford, H. W., and Beville, B. C.
Citrus Experiment Station, Lake Alfred, Florida.
Transactions of the American Society of Agricultural Engineers, Vol. 11, No. 1, p 41-42, January-February, 1968. 1 tab, 8 ref.

Descriptors: Drainage, *Tile drainage, Drainage system, *Soil chemical properties, Ditches, Backfill, Filters, *Sawdust, Hydrogen sulfide, Iron compounds, Anaerobic conditions, *Iron bacteria.
Identifiers: *Slag.

The rapid destruction of slag gravel filters under continuous flow was initiated by H2S, a bacterial metabolite formed under suitable conditions in an anaerobic flooded environment. Bisulfide ions apparently reacted with calcium in the slag, destroying the buffering capacity as well as physical structure. FeS accumulated as deposits around slag and sawdust filters and may be the principal factor reducing infiltration rates. Heavy deposits in the soil were present only on topsoil organic matter used to "blind" the tile. FeS observed in the surface of seepage zone of ditch banks may have an adverse effect on hydraulic conductivity.

68-69:02F-047
GROUND WATER MANAGEMENT AND RECLAIMED WATER,
Owen, L. W.
Orange County Water District, Santa Ana, California.
Journal of American Water Works Association, Vol. 60, No. 2, p 135-144, February 1968.
2 fig, 1 tab.

Descriptors: *Ground water, Waste water (Pollution), Reclaimed water, Water management (Applied), Water reuse, Water supply.

Studies by the Orange County Water District have attempted to view the overall water management problem and develop a program to meet reasonable objectives. In order to understand the contemplated use of wastewater reclamation in this or any area, the overall water requirement and supply problems have been evaluated. With the six water sources and technologic capability available to the Orange County Water District there are many possible ways to meet water quantity and quality requirements. The challenge is to find the most economical method consistent with public safety. The future role of wastewater reclamation will depend upon the need, feasibility, and economics of the treatment process.

68-69:02F-048
MOVEMENT OF SALT IN SATURATED SOILS COLUMNS,
Mokady, R. S., Ravina, I., and Zaslavsky, D.
Israel Institute of Technology, Haifa.
Israel Journal of Chemistry, Vol. 6, p 159-165, 1968. 3 fig, 3 ref.

Descriptors: *Saturated soils, *Salts, *Calcium chloride, Porous media clays, Chromatography, Hydrodynamics.
Identifiers: Malkia clay soil.

The leaching of salts through porous media is described using the theory of hydrodynamic dispersion on chromatography. Calcium chloride solutions were passed through a saturated non-expanding clacium clay soil. The breakthrough curves were found to depend on the $CaCl_2$ concentrations and on the rate of flow. The results are explained by ion exclusion and hydrodynamic dispersion mechanisms.

68-69:02F-049
THEORY OF FLOW IN AQUICLUDES ADJACENT TO SLIGHTLY LEAKY AQUIFERS,
Neuman, S. P., and Witherspoon, P. A.
California University, Berkeley, Department of Civil Engineering.
Water Resources Research, Vol. 4, No. 1, p 103-112, February 1968. 5 fig, 14 ref.

Descriptors: *Groundwater, *Aquifers, *Aquicludes, Wells, Drawdown.
Identifiers: *Hydrologic systems, Theis solution.

The theory of flow in aquicludes that are adjacent to slightly leaky aquifers is presented for two cases: (a) aquicludes of finite thickness, and (b) aquicludes of semi-infinite thickness. By slightly leaky, we simply mean that when the aquifer is being pumped at constant rate, the drawdowns in the aquifer will be predicted by the Theis solution, even though some slight movement of water through adjacent confining beds occurs. It is assumed that flow is essentially horizontal in the aquifer and vertical in the aquiclude. On this basis, analytical expressions for drawdown in the aquiclude are developed for each case. The results are presented in the form of type curves that can be used for aquiclude evaluation. The effect of multiple-well fields is considered in each case.

68-69:02F-050
AGRICULTURE'S EFFECT ON NITRATE POLLUTION OF GROUNDWATER,
Stewart, B. A., Viets, F. G., and Hutchinson, G. L.
Agricultural Research Service, Fort Collins, Colorado.
Journal of Soil and Water Conservation, Vol. 23, No. 1, p 13-15, January-February 1968. 1 fig, 1 tab, 8 ref.

Descriptors: *Nitrate, *Water pollution, *Fertilizers, *Soil profiles, *Groundwater, *Agriculture, *Wastes, Alfalfa, Grasslands.
Identifiers: Irrigated row crops, Domestic wells, Feedlots.

Contributions of fertilizers applied to soil and wastes from concentrated livestock feeding operations to pollution of groundwater were studied in the middle South Platte River Valley in Colorado. Amounts of nitrate moving through 129 soil profiles studied varied widely with land use. Average total nitrate N to a depth of 20 ft in lbs/acre was 1436 under feedlots, 506 under irrigated row crops, 261 under dryland row crops, 90 under native grassland, and 79 under alfalfa. The average annual loss of N to groundwater under irrigated row crops was estimated at 25 to 30 lbs/acre. Feedlots located near homesteads had much more effect on nitrate content of water from domestic wells than did cropped land.

SECTION V

WATER CYCLE - WATER IN SOILS (Group 02G)

68-69:02G-001
DISPERSION AT THE INTERFACE OF MISCIBLE LIQUIDS IN A SOIL,
Li, W. H., and Yeh, G. T.
Syracuse University, Syracuse, New York.
Water Resources Research, Vol. 4, No. 2, p 369-377, April 1968. 7 fig, 10 ref.
(See 68-69:02F-001)

68-69:02G-002
ENTRY VELOCITY CONTROL LIMITS DRAIN SEDIMENTATION,
Willardson, L. S., Fouss, J. L., Reeve, R. C., and Fansey, N. R.
Agricultural Research Service, Brawley, California.
Journal of the Irrigation & Drainage Division, ASCE, Vol. 94, No. IR4, December 1968.
4 fig, 1 tab, 10 ref.
(See 68-69:02F-003)

68-69:02G-003
INFILTRATION RATES AS AFFECTED BY DESERT VEGETATION,
Lyford, Forest P., and Qashu, Hasan K.
Arizona University, Tucson.
Water Resources Research, Vol. 5, No. 6, p 1373-1376, December 1969. 3 fig, 3 tab,
4 ref.

Descriptors: *Infiltration, *Vegetation effects, *Arid lands, Soil-water-plant relationships, On-site tests, Soil water movement.
Identifiers: Paloverde, Creosote bush.

Infiltration of water into two soils measured at radial distances from the stems of paloverde (Cercidium microphyllum) and creosote bush (Larrea tridentata) were found to average nearly three times greater under plants than in the openings. Bulk density was lower and organic matter content was higher in topsoil under plants than in the openings.

68-69:02G-004
IRRIGATION INVESTIGATIONS IN OTAGO, NEW ZEALAND, IV. PHYSICAL PROPERTIES OF SOILS OF THE ARROW BASIN AND UPPER CLUTHA VALLEY,
Rickard, D. S., and Cossens, G. G.
Winchmore Irrigation Research Station, Private Bag, Ashburton, Dept of Agriculture.
New Zealand Journal of Agricultural Research, Vol. 11, p 701-732, 1968. 5 fig,
11 tab, 4 ref.

Descriptors: *Soil physical properties, *Irrigation, *Soil horizons, Rainfall, Available moisture, Wilting point, *Soil analysis.
Identifiers: New Zealand, *yellow-brown earth, *yellow-grey earth.

Physical properties, including the percentage of fine particles, organic carbon, 15-bar retention, field capacity, and available moisture show consistent increases between virgin soil groups formed under semi-arid (brown-grey earths), sub-humid (yellow-grey earths), and humid (yellow-brown earths) climates. Bulk density values decrease throughout the same sequence. There is a tendency for similar changes to occur with soils of increasing ground surface age within the brown-grey earths. There is an insufficient range of ground surface ages to establish this tendency for the other groups. Irrigation and associated management have tended to alter the properties of a particular soil group in the direction of those of the group formed under a higher rainfall. This tendency is not true for the bulk density, which is in most cases higher under irrigation. The available moisture held in the top 12 in. of the soils studied ranged from 1.58 in. to 4.30 in. If irrigation was applied at the wilting point, the soils in the three zonal groups would retain the following approximate amounts: brown-grey earths, 2 in. to 2½ in.; yellow-grey earths, 2½ in. to 3½ in.; yellow-brown earths, 3 in. to 4 in.

68-69:02G-005
DRAINAGE WITH PERFORATED PLASTIC TUBING,
Klock, G. O., Boersma, L., Watts, D. G., and Brooks, R. H.
Forest Hydrology Laboratory, Wenatchee, Washington.
Agronomy Journal, Vol. 61, No. 1, p 56-68, January-February, 1969. 3 fig, 1 tab, 4 ref.

Descriptors: *Drainage, *Subsurface drainage, *Alfalfa, *Manganese, *Water table.
Identifiers: Plastic tubing.

The feasibility of placing drains at shallow depths and close together to improve drainage conditions on a planosol was evaluated. Field lysimeters were obtained by surrounding soil blocks with vertical sheets of heavy plastic penetrating well into the impermeable subsoil. Perforated plastic tubing placed 22.5 feet (approx. 6.9 m) apart at a depth of 20 inches (approx. 51 cm) provided adequate drainage. Dupuit alfalfa yielded better than 10 T/A dry matter. Manganese levels were below concentrations considered toxic. When a spacing of 45.0 feet (approx. 13.7 m) was used, the alfalfa yields were greatly reduced, and the manganese concentrations were well above levels considered toxic.

68-69:02G-006
TRANSPORT IN SOILS: THE BALANCE OF MOMENTUM,
Raats, P. A. C., and Klute, A.
Agricultural Research Service, Madison, Wisconsin.
Soil Science Society of America Proceedings, Vol. 32, No. 4, p 452-456, July-August, 1968. 30 ref.

Descriptors: *Soil physics, *Darcy's Law, *Soil moisture, *Flow, *Momentum equation, Saturated soils, Unsaturated flow.
Identifiers: *Balance of forces, *Deformable soils, Continuum theory.

The mechanics of the fluid phase(s) of a soil is discussed on the basis of a balance of momentum for each phase. Saturated as well as unsaturated soils are considered. It is shown that with certain assumptions the balance of momentum for a fluid phase reduces to Darcy's Law. The meaning and some possible generalizations of the various assumptions are considered. The form of Darcy's Law appropriate to soils whose solid phase undergoes a deformation is deduced.

68-69:02G-007
EFFECT OF WATER TABLE DEPTH AND FLOODING ON YIELD OF MILLET,
Williamson, R. E., Wiley, C. R., and Gray, T. N.
U.S. Department of Agriculture, Raleigh, North Carolina.
Agronomy Journal, Vol. 61, No. 2, p 310-313, March-April, 1969. 4 fig, 2 tab, 16 ref.

Descriptors: *Drainage, *Aeration, Flooding.

Yields of millet (Pennisetum glaucum (L.)R. Br.) grown in both sheltered and nonsheltered soil tanks increased with water table depth to a depth of 76 cm. In the sheltered tanks yields were similar for all water table depths greater than 61 cm. The N, P, and K contents of plants grown with water tables at 15 or 30 cm in the sheltered tanks were significantly lower than for deeper water table depths. Except for the tanks with 15- and 30-cm water tables, the oxygen content by volume was generally above 18% at the 15-cm depth, indicating that the region of greatest root mass (0 to 8 cm) was probably well aerated. Since yields were affected by water table depths down to 76 cm, it appears that the few roots extending below the 8-cm depth were nevertheless necessary to supply nutrients to the plant. Yield data suggest that O_2 was low in a portion of the root zone where water tables were less than 76 cm below the surface. Two days of flooding 4 weeks before the first harvest reduced the first harvest yield 40%, but did not affect the second harvest yield. Flooding at earlier or later dates caused less yield reduction.

68-69:02G-008
INTERDEPENDENCE OF WATER DROP ENERGY AND CLOD SIZE ON INFILTRATION AND CLOD STABILITY,
Moldenhauer, W. C., and Kemper, W. D.
Iowa State University, Ames, Dept of Agronomy.
Soil Science Society of America Proceedings, Vol. 33, No. 1, p 297-301, January February, 1969. 8 fig, 3 tab, 17 ref.

Descriptors: *Infiltration, *Impact (Rainfall), *Soil structure, *Soil surface, *Runoff, Soil erosion.
Identifiers: Soil surface sealing.

The decline of intake rates as successive increments of water drop energy were applied to various sizes of soil fragments of two Iowa and two Colorado soil types is presented. There was a wide spread between intake rate of the 8- to 20-mm size range and those of all other sizes after the first increment (1.25 cm as 5-mm drops) was applied. The intake rate of the 8- to 20-mm size declined rapidly after the first or second increment. Final intake rates were not correlated with aggregate stability in this study. There was a negative correlation between clay content and final intake rates. Final intake rates after disintegration of large soil fragments in many cases were lower than when initial size ranges were small.

68-69:02G-009
THE PREDICTION OF EVAPORATION, DRAINAGE, AND SOIL WATER STORAGE FOR A BARE SOIL,
Black, T. A., Gardner, W. R., and Thurtell, G. W.
Wisconsin University, Madison, Dept of Soil and Water Science.
Soil Science Society of America Proceedings, Vol. 33, No. 5, p 655-660, September - December, 1969. 8 fig, 18 ref.

Descriptors: *Evaporation, *Drainage, *Infiltration, *Soil moisture, Capillary action, Lysimeters, Irrigation, Deep percolation, Diffusivity, Water storage, Water loss, Soil water.
Identifiers: Plainfield sand, Conductivity.

Evaporation, drainage, and changes in storage for a bare Plainfield sand were measured with a lysimeter during June, July, and August, 1967, under natural rainfall conditions. Cumulative evaporation at any stage was proportional to the square root of time following each heavy rainfall. The drainage rate was found to be an exponential function of water storage. Both relations can be predicted from flow theory with knowledge of soil capillary conductivity, diffusivity, and moisture retention characteristics. Using these two relations and daily rainfall data, the water storage in the top 150 cm was predicted over the season to within 0.3 cm.

68-69:02G-010
RELATION OF WATER APPLICATION TO EVAPORATION AND STORAGE OF SOIL WATER,
Gardner, H. R., and Gardner, W. R.
Agricultural Research Service, Fort Collins, Colorado.
Soil Science Society of America Proceedings, Vol. 33, No. 2, p 192-196, March - April, 1969. 8 fig, 1 tab, 7 ref.

Descriptors: *Evaporation, *Water storage, *Diffusivity, Rainfall, Irrigation.
Identifiers: Rago loam, McGrew sandy loam.

Evaporation was measured from columns of Rago loam and McGrew loamy sand, to which water had been added at several rates ranging from 0.25 cm/day to 10.2 cm every 20 days. The water lost by evaporation varied from 100% of the total applied for the smallest and most frequent addition to 31.2% for the 10.2 cm of water added to McGrew soil every 20 days. The losses from repeated cycles of the individual treatments tended to approach a constant value that was less than the potential loss. As the amount added was increased for a given evaporation period, the loss tended to approach a constant value that also was much less than the potential loss. The cumulative evaporation curves were scaled to dimensionless variables and compared with a theoretical solution of the diffusivity equation for finite media. Using this scaling-comparison technique, the losses from soil with two different potential evaporations were compared with predicted curves.

68-69:02G-011

FACTORS IMPORTANT IN THE CALCULATION OF HYDRAULIC CONDUCTIVITY,

Kunze, R. J., Uehara, G., and Graham, K.
Michigan State University, East Lansing, Dept of Soil Science.
Soil Science Society of America Proceedings, Vol. 32, No. 6, p 760-765, November-December, 1968. 8 fig, 1 tab, 12 ref.

Descriptors: *Soil moisture, *Hysteresis, Pressure head, Computer.
Identifiers: Millington-Quirk method, Matching factor.

The calculation of hydraulic conductivity by a modified Millington-Quirk method with a matching factor gave conductivity values closely approximating experimentally measured values. The technique requires knowledge of the moisture characteristic and the saturated conductivity. A number of factors that affect the calculated values and improve the computational results were investigated. Calculated conductivity values decreased with an increasing number of pressure classes at low moisture contents. For all soils tested, the calculated conductivities were less than the experimental values at the terminal point of the moisture characteristic. This discrepancy was partially corrected by a small change in the Millington-Quirk equation, by extending the moisture characteristics to higher suction values, and by reducing the number of pressure classes to approximately 10. A matching factor, the ratio of measured over calculated saturated conductivity, was found necessary for obtaining the best fit of calculated and measured data. Two conductivity functions calculated separately from each moisture characteristic forming a hysteresis loop converged as the hysteresis loop was translated to higher tensions. All computations were done by computer.

68-69:02G-012

SOIL MOISTURE CONTENT, TILTH, AND SOYBEAN RESPONSE WITH SURFACE AND SUBSURFACE DRAINAGE,

Fausey, N. R., and Schwab, G. O.
Agricultural Research Service, Wooster, Ohio.
Agronomy Journal, Vol. 61, No. 4, p 554-557, July-August, 1969. 5 fig, 5 ref.

Descriptors: *Penetration, *Soil moisture, *Subsurface drainage, *Surface drainage.
Identifiers: Soil crust, Soybean yield, Soybean roots.

Soil properties and soybean response were compared for plots having different levels of drainage. The plots were established on a silty clay lakebed soil in northern Ohio. The soil and crop characteristics compared were: (1) average soil moisture content at four depths in the upper 30 cm during the seedbed preparation period (April and May); (2) soil tilth immediately preceding seedbed preparation as expressed by crust properties and resistance to surface penetration; and (3) stand establishment, root and top growth, and soybean yield. On plots with no drainage, crop stand was sparse and crop growth essentially nil. There were long periods with ponded water, and crusting and adverse structure of the surface soil were much in evidence. Among drained plots, there were no measurable differences in crust bulk density and soybean stand. Plots having subsurface or combined surface-subsurface drainage had lower moisture content, less resistance to surface penetration, smaller crust units, taller plants, better developed root systems, and greater yields than plots with surface drainage alone.

68-69:02G-013

EXPERIMENTAL EVALUATION OF INFILTRATION EQUATIONS,

Skaggs, R. W., Huggins, L. E., Monke, E. J., and Foster, G. R.
Purdue University, Lafayette, Indiana, Dept of Agricultural Engineering.
American Society of Agricultural Engineers, 1968 Annual Meeting, Paper No. 68-213, Logan, Utah June 1968. 26 p, 6 fig, 3 tab, 18 ref.

Descriptors: *Infiltration, *Experimental data, Analysis, Soils, Time, Soil erosion, Surface runoff, Bibliographies, Erosion, Field tests, Soil moisture, Soil physical properties, Runoff, Soil science, Agriculture, Hydrology.
Identifiers: Evaluation, Rainfall-runoff relation, *Infiltration rate, Equations, Rainfall simulators, Wetting front, Regression analysis.

An analysis of infiltration equations proposed by Green and Ampt, Hortan, Phillip, and Holtan was made using experimental data obtained in erosion studies with a plot size rainfall simulator. An overland flow analysis was used to determine the infiltration rate-time relationship from the runoff hydrograph. Regression fits of the four equations to experimental data for 52 tests on 13 soils showed that all of the equations adequately described the infiltration rate-time relationship. Values of the equation parameters for each run analyzed are presented in the paper.

68-69:02G-014
SOLVING THE NON-LINEAR DIFFUSION EQUATION FOR THE RADIAL FLOW OF WATER TO ROOTS,
Passioura, J. B., and Cowan, I. R.
C.S.I.R.O., Division of Land Research, Canberra City, A.C.T., Australia.
Agricultural Meteorology, Vol. 5, p 129-134, 1968. 3 fig, 6 ref.

Descriptors: *Diffusion, *Soil water movement, *Flow, *Root systems, Model studies.
Identifiers: *Radial flow.

The non-linear diffusion equation for the radial flow of water to a root can be solved approximately by assuming that $\partial\theta/\partial t$ is either zero (steady state) or constant (steady rate). The accuracy of such solutions has been in doubt, so they are here compared with exact solutions obtained numerically. It is shown that the approximate solutions agree well with the numerical ones for biologically possible conditions. The "steady rate" method is somewhat more accurate than the "steady state" one.

68-69:02G-015
TILLAGE INFLUENCES WATER INTAKE,
Burwell, R. E., Sloneker, L. L., and Nelson, W. W.
Agricultural Research Service, Morris, Minnesota.
Journal of Soil & Water Conservation, Vol. 23, No. 5, p 185-187, September-October, 1968. 3 tab, 9 ref.

Descriptors: *Cultivation, *Soil surfaces, *Infiltration, *Runoff, *Weathering, Soil treatment, Loam, Clay loam, Soil texture, Soil erosion, Soil moisture, Mulching, Water storage, Artificial precipitation.
Identifiers: *Roughness (Soil), Sealing.

The studies were conducted to determine the influence of different tillage methods on soil surface condition and subsequent infiltration. Artificial rainfall was applied at the rate of 5 inches per hour to various surface conditions on loam, clay loam and sandy clay loam. Surface conditions were created by moldboard plowing, moldboard plowing-disking-harrowing, rotary tillage and mulch tillage. Infiltration before runoff started on freshly-tilled bare surfaces increased as tillage-induced random roughness increased. Infiltration was not closely related to this roughness after rainfall or fall-to-spring weathering caused surface seal development. Infiltration before runoff began was twice as high on freshly plowed surfaces as on freshly plowed-disked-harrowed surfaces. Fall mulch-tilled surfaces provided eight times greater infiltration capacity before runoff started and four times greater infiltration during runoff the following spring than did fall plowed surfaces which were disked and harrowed in the spring. The tillage-infiltration relationships that were studied could possibly be used to increase infiltration and reduce the runoff from arid soils.

68-69:02G-016
PSYCHROMETRIC MEASUREMENT OF SOIL WATER POTENTIAL IN SITU UNDER COTTON PLANTS,
Lang, A. R. G.
Commonwealth Scientific and Industrial Research Organization, Griffith (Australia).
Soil Science, Vol. 106, No. 6, p 460-464, December 1968. 4 fig.

Descriptors: *Soil moisture, Soil water movement, *Moisture content, *Cotton, *Hygrometry, Soil-water-plant relationships, Root systems, *Measurement, Instrumentation, Moisture uptake, Variability, Temperature, Absorption, Diurnal, Nocturnal, Translocation.
Identifiers: *Soil water potential, Water potential, *Psychrometers.

Water potentials were measured directly and continually at 9 different positions in 16 liter volumes of soil, while water was removed via the roots of intact cotton plants in Australia. Measurements were made using Spanner thermocouple psychrometers inserted into cages previously buried in the soil. Water potentials displayed the expected patterns: water potential decreased more rapidly during the day than night, while day by day it decreased. The results confirmed by direct measurement that cotton plants continue to withdraw water from soils at soil water potentials less than -3000J kg super -1. The apparatus, which may have application in the field, and the variability of results were discussed in detail Part of the variability was probably caused by uneven distribution of roots. The probable error of the mean water potential at a given time was small relative to the changes in water potential with time.

68-69:02G-017
ADSORPTION OF SODIUM FROM IRRIGATION WATER BY FOUR TEXAS SOILS,
Thomas, Grant W., and Yaron, Bruno.
Texas A&M University, College Station.
Soil Science, Vol. 106, No. 3, p 213-219, September 1968. 6 fig, 4 tab.

Descriptors: *Sodium, Alkaline water, *Adsorption, Saline water, *Soil chemistry, Leaching, Electrolytes, Chromatrography, Equilibrium, Mineralogy, *Irrigation water, *Cation exchange, Clay minerals, Flow rates, Texas, Hydraulic conductivity.
Identifiers: *Soil columns.

The adsorption of sodium from saline water during flow through chromatographic columns was studied utilizing four soil types from Texas having different soil mineralogy texture and cation exchange capacity. Eight synthetic and two natural well waters were used to leach the soils. It was concluded that the relationship between SAR and ESP of soil did not give a significant correlation when sodium containing water flowed through soil columns. The exception was the surface of the soil. The total electrolyte concentration of the sodic water influenced the rate of sodium adsorption. At equilibrium soil mineralogy and the cationic composition exerted a greater influence over the exchangeable sodium percentages. Mica and montmorillonitic soils had a greater affinity for Na than did montmorillonitic soils. Flow of water in field conditions from equilibrium hydraulic conductivity could not be determined.

68-69:02G-018
ANALYSIS OF VARIATIONS IN SOIL MOISTURE STORAGE IN ROW CROP PLANTINGS AS A FUNCTION OF AGROMETEOROLOGICAL FACTORS,
Kleshchenko, A. D., and Chirkov, Yu. I.
State Hydrological Institute, Leningrad (USSR).
Soviet Hydrology Selected Papers No. 3, p 270-277, 1968. 3 tab, 11 ref., Translated from Trudy Gidro-meteorologcheskogo nauchno-issledovatel' skogo tsentra SSSR, No. 14, p 107-116, 1968.

Descriptors: *Soil moisture, *Soil-water-plant relationships, *Water storage, *Vegetation effects, *Meteorology, Correlation analysis, Regression analysis, Evapotranspiration, Moisture content, Statistical methods, Correlation analysis, Regression analysis.
Identifiers: USSR.

Meteorological observations in Moscow and Kaluga provinces were related to soil moisture content and row crop data by multiple regression analysis. The meteorological data used were air temperature, relative humidity, moisture deficit, wind force, clouds, number of days with precipitation, and the amount of precipitation. Crop data were leaf surface area, density of planting, stage of plant development and soil moisture, in corn and potatoes. Correlation coefficients were calculated and tabulated. The variation in soil moisture was determined mainly by precipitation, number of rainy days, and cloudiness, and less by the stage of plant development, initial moisture and wind velocity.

68-69:02G-019
SOIL HYDRAULIC CONDUCTIVITY AS AFFECTED BY SODIC WATER,
Yaron, Bruno, and Thomas, Grant W.
Texas A&M University, College Station.
Water Resources Research, Vol. 4, No. 3, p 545-552, June 1968. 6 fig, 3 tab, 12 ref.

Descriptors: *Hydraulic conductivity, Water quality, Permeability, Pervious soils, Porosity, *Saturated flow, Soil chemical properties, Soil water movement, *Soil water, Irrigation, Bentonite, Expansive clays, Expansive soils, Ion exchange, Leaching.
Identifiers: *Sodic water, Swelling clays, NA-bentonite, Experimental soil systems.

The hydraulic conductivities of mixtures of soil and glass beads in columns were determined during the flow of dilute sodium-calcium solutions through the mixtures. Flow was continued until equilibrium was achieved. A curvilinear decrease in hydraulic conductivity was found as the exchangeable sodium approached equilibrium. The shape of the curve depended on the nature of the soil and the cationic composition and total salt content of the solutions. The hydraulic conductivity became constant only when a constant exchangeable sodium content was achieved along the soil column. A semiempirical method of predicting the hydraulic conductivity was developed. Agreement between calculated and observed values was found to be reasonably good.

68-69:02G-020
A NUMERICAL METHOD FOR ESTIMATING INFILTRATION, REDISTRIBUTION, DRAINAGE AND EVAPORATION OF WATER FROM SOIL,
Hanks, R. J., and Klute, A.
Agricultural Research Service, Fort Collins, Colorado.
American Society of Agricultural Engineers, Annual Meeting, Paper No. 68-214, Logan, Utah, June 1968. 16 p, 7 fig, 1 tab, 8 ref.

Descriptors: *Numerical method, *Infiltration, Drainage, *Evaporation, Moisture content, Soils, *Soil moisture, Computer programming, Boundary values, Hysteresis, Water table, Diffusion, Soil science, Wetting and drying tests.
Identifiers: Soil columns, Soil moisture movement, One-dimensional, *Soil-water relationship, Potential evaporation, Conductivity.

A numerical method was developed for estimating one-dimensional infiltration of water into soil where water added by precipitation at the surface was equal to or greater than the infiltration rate. The method estimated redistribution of water within the soil after precipitation had stopped, taking into account hysteresis in the water content-pressure relation. Drainage into a water table was considered. The method allowed for evaporation at a rate determined by external climatic conditions or at a rate determined by internal soil conditions. Graphs are given of: (1) water content-pressure relations; (2) cumulative flow-time relations and water content profiles for an infiltration, redistribution, evaporation problem; (3) water content profiles after redistribution, using wetting and drying curves with and without hysteresis; and (4) cumulative flow, water content profiles, and pressure profiles for a drainage evaporation problem.

68-69:02G-021
SALT AND WATER BALANCE, COACHELLA VALLEY, CALIFORNIA,
Bower, Charles A., Spencer, James R., and Weeks, Lowell O.
Agricultural Research Service, Riverside, California.
Journal of Irrigation & Drainage Division, ASCE, Vol. 95, No. IR1, Proc Paper No. 6437, p 55-64, March 1969. 2 fig, 4 tab, 6 ref.

Descriptors: *Irrigated land, *Drainage effects, *Salt balance, *Water balance, *Leaching, Drainage water, Irrigation effects, Drains, Salts, California, Arid lands, Evapotranspiration, Soil chemistry, Tile drains, Input-output analysis, Ions.
Identifiers: *Coachella Valley, California, Salt balance index.

This study reported salt and water balance conditions in irrigated land by years for the period 1957-1965, and compared measured and calculated values for leaching and evapotranspiration, as well as indicating nature and extent of chemical reactions occurring in soil as a consequence of irrigation. The salt balance index (output/input) for irrigated land was highly related to both area of irrigated land having tile drainage and leaching percentage, the index becoming close to one when about half the land became tiled and when leaching percentage increased to about 30. At salt balance evapotranspiration, taken as the difference between depths of applied and drainage water, agreed within about 10% of that calculated by the Blaney-Criddle formula. About 10% of the applied salt appeared to precipitate in soil largely as calcium carbonate and magnesium in water replaced exchangeable sodium in soil during irrigation operations.

68-69:02G-022
THE VERTICAL MOVEMENT OF WATER IN STRATIFIED POROUS MATERIAL. 1. INFILTRATION,
Childs, E. C., and Bybordi, M.
Agricultural Research Council, Cambridge (England).
Water Resources Research, Vol. 5, No. 2, p 446-459, April 1969. 9 fig, 1 tab,
14 ref.

Descriptors: *Infiltration, *Soil water movement, *Unsaturated flow, Soil profiles, Permeameters, Mathematical models, Percolation, Model studies, Hydraulic models.
Identifiers: Heterogeneous soil profiles, Vertical permeability.

The infiltration law of Green and Ampt is extended to include heterogeneous profiles. Formulas are developed to express 3 relationships. The infiltration law is derived for a profile consisting of a succession of n different layers with conductivity decreasing from the surface. An expression is derived for the conductivity profile that will give a specified infiltration law, and in particular a linear infiltration law with specified parameters. This expression serves to determine the conductivity when the infiltration law is observed. Experiments are described to measure the infiltration rates into layered columns or porous material, the results of which confirm the theory.

68-69:02G-023
SUBSURFACE DRAINAGE BY TRANSIENT-FLOW THEORY,
Dumm, Lee D.
Bureau of Reclamation, Denver, Colorado.
ASCE Proc., Journal of Irrigation & Drainage Division, Vol. 94, No. IR4, Paper No.
6315, p 505-519, December 1968. 12 fig, 6 tab, 13 ref.

Descriptors: *Subsurface drainage, *Mathematical studies, *Unsteady flow, *Drawdown, Groundwater, Seepage, Discharge (Water), Irrigation, Water balance, Hydrologic budget, Evapotranspiration.
Identifiers: Drain spacing, Transient flow theory.

The transient-flow theory is used as a basis for determining spacing relationships of subsurface drains. Steady-state flow theory does not adequately describe the changing conditions of subsurface drainage. Research work from Australia and Canada and data from a Bureau of Reclamation project were used for checking the validity of the mathematical developments of the transient-flow theory under many varying field conditions. An actual field problem is given as an example of how field investigational data and other available data are used in developing drain-spacing requirements under various specified conditions. Discharge formulas are given and their validity is verified by the Australian and Canadian research work.

68-69:02G-024
LEACHING REQUIREMENT FOR EXCHANGEABLE-SODIUM CONTROL,
Rhoades, J. D.
Agricultural Research Service, Riverside, California.
Soil Science Society of America Proceedings, Vol. 32, No. 5, p 652-656, September-
October 1968. 4 fig, 2 tab, 16 ref.

Descriptors: *Irrigation water, *Sodium, *Leaching, *Cation exchange, *Equations, Drainage water, Water quality, Saline water, Salts, Root zone, Permeability, Adsorption, Soil water, Salinity, Arid lands, Lime, Salt tolerance.
Identifiers: *Leaching requirement, Sodium adsorption ratio, Sodium hazard.

Estimation of the leaching fraction required to maintain the SAR (Sodium-Adsorption Ratio) in irrigation water at the lower limit of the plant-rooting zone below some limiting value was described. Plant tolerances to sodium and soil permeability regulate the limiting SAR. Prediction of SAR values for a calcareous soil was accomplished by use of a formula equating the leaching requirement for salinity control from irrigation and soil waters.

68-69:02G-025
CHARACTERIZATION OF SOIL AERATION DURING SPRINKLER IRRIGATION,
Stegman, E. C., Erickson, A. E., and Kidder, E. H.
North Dakota State University, Fargo , Dept of Agricultural Engineering.
American Society of Agricultural Engineers, Transactions, Vol. 11, No. 1, p 16-20, January-February 1968. 6 fig, 2 tab, 20 ref.

Descriptors: *Sprinkler irrigation, *Aeration, *Infiltration, *Saturation, *Rates of Application, Soil moisture, Soil structure, Irrigation, Irrigation water, Irrigation efficiency, Irrigation practices, Oxygen, Pores.
Identifiers: *Soil aeration, *Pore space saturation, *Soil oxygen deficiency, *Oxygen diffusion rate, *Soil intake rate, Desorption.

Various investigators have concluded that there are beneficial effects when sprinkler irrigation systems apply water at rates well below the normal soil intake rate. Data suggest that decreased soil saturation reduces soil oxygen deficiency. Therefore a study was undertaken to develop a practical technique of evaluating aeration adequacy of soils during irrigation. It was first necessary to know the degree of pore space saturation which could be tolerated by a given soil. This could be realistically evaluated by combining oxygen diffusion rate measurements with a soil-moisture-retention test. Infiltration tests were conducted and it was clearly demonstrated that the rate of application influenced the degree of profile saturation. A feasible application rate existed such that degree of pore space saturation was not exceeded in the transmission zone of each of the soils tested.

68-69:02G-026
EFFICIENT WHEAT IRRIGATION WITH LIMITED WATER,
Schneider, A. D., Musick, J. T., and Dusek, D. A.
Southwestern Great Plains Research Center, Bushland, Texas.
Transactions of the ASAE, Vol. 12, No. 1, p 23-26, January 1969. 5 fig, 4 tab, 7 ref.

Descriptors: *Irrigation efficiency, *Wheat, *Crop production, *Water utilization, *Growth stages, Timing, Soil moisture, Irrigation water, Texas, Plant physiology, Moisture stress, Moisture deficit, Soil-water-plant relationships, Winter, Rates of application, Moisture availability, Precipitation (Atmospheric).

A study was conducted at Bushland, Texas during three wheat seasons to determine the combinations of spring irrigations at four selected stages of plant development that produced the best water-use efficiencies and to determine some effects on yields and plant development caused by delaying or deleting irrigations. The study showed that irrigation timing was critical when less than an optimum amount of water was applied to winter wheat. Every number and timing of the four irrigations was used so that the effect of any combinations of irrigations could be evaluated. The most critical period for adequate soil moisture was from booting through early grain filling. Moderate soil-moisture stress during early spring did not reduce yields appreciably if soil moisture was adequate during this critical period.

68-69:02G-027
WATER RELEASE AS A SOIL PROPERTY RELATING TO USE OF WATER BY PLANTS,
Richards, Sterling J.
California University, Riverside, Dept of Soil Physics.
American Society of Agricultural Engineers, Transactions, Vol. 11, No. 1, p 74-75, 1968. 4 fig, 5 ref.

Descriptors: *Moisture availability, Irrigation practices, Retention, Soil aggregates, Soil classification, Soil horizons, Soil structure, Field capacity, Wilting point, Tensiometers, Water storage, Moisture tension, Sudangrass, Water-plant relationships, Soil mechanics.
Identifiers: *Water-release curves, Resistance block.

The volume fraction of soil water released to growing plants is proposed as a soil property for comparing soils or evaluating structural changes in a soil. Water release is measured as a function of soil suction, utilizing a tensiometer and a resistance block. A procedure utilizing soil containers and Sudangrass is detailed. Because most field situations present various soil horizons and rooting characteristics of crops soil-water depletion varies with depth, it is recommended that tensiometers or blocks be used in each recognized soil horizon and separate water release curves be drawn. Total irrigation water depth would be the sum of all the horizons.

Examples of water-release curves are given for three soils with widely varying textures. Two soils, in spite of wide differences in texture, had almost identical water-release curves. Treatment of one soil with an aggregating agent, VAMA, resulted in a marked increase in water release. Water release curves appear to have advantages over other procedures for evaluating the property of a soil to store water for plant use.

68-69:02G-028
CONTINUOUS MONITORING OF SOIL MOISTURE TENSION PROFILES,
Bianchi, W. C., and Tovey, Rhys.
American Society of Agricultural Engineers, Transactions, Vol. 11, No. 3, p 441-443, 447, May-June 1968. 10 fig, 6 ref.

Descriptors: *Moisture tension, *Monitoring, *Measurement, *Tensiometers, *Equipment, Irrigation, Tension, Soil moisture, Soil water, Strain gages, Lysimeters, Manometers, Instrumentation, Calibrations, On-site data collections, Pressure, Electrical equipment.
Identifiers: *Soil moisture tension, *Pressure transducers, *Transducers, Scanning systems.

Although conventional gage or manometer-type tensiometers cannot be used for long-term measurement of changes in soil moisture tension, pressure transducers can be effectively employed. Minimum-cost hydraulic scanning and electronic scanning systems were studied and soil moisture tensions under irrigated alfalfa were measured. Multipoint electronic scanning of many individual strain-gage tensiometers yielded reliable field data throughout the growing season. In order to attribute soil moisture tension changes directly to changes in evapotranspiration, it is necessary to thermally isolate the measurement system. Zero shift of the transducers is the most important limitation of the pressure transducer system. External means of zero calibration are required, such as raising or creating a water table above transducers in lysimeters.

68-69:02G-029
ANALYSIS OF INFILTRATION INTO DRAINING POROUS MEDIA,
Whisler, Frank D., and Watson, Keith K.
Agricultural Research Service, Phoenix, Arizona.
American Society of Civil Engineers, Proceedings, Journal of Irrigation & Drainage Division, Vol. 95, No. IR4, Paper No. 6946, p 481-491, December 1969. 13 fig, 10 ref, append.

Descriptors: *Infiltration, *Drainage, *Groundwater movement, *Soil water movement, Flooding, Irrigation, Water spreading, Numerical analysis, Saturated flow, Filtration, Hysteresis, Wetting, Drying, Recharge, Sands, Mathematical studies.
Identifiers: Wetting fronts.

Numerical analysis was applied to the inundation of a draining sand column. A method was proposed whereby hysteresis could be considered. For Botany sand, after periods of short drainage between inundations, infiltration is rapid. For longer periods of drainage, the ensuing infiltration is slower, but the water moves through the media with a much steeper front. The effects of hysteresis are dynamic, depending upon the stage of drainage and the relationship used. Using a strictly wetting curve gives a better prediction than a strictly draining curve.

68-69:02G-030
INFILTRATION OF WATER INTO NONUNIFORM SOIL,
Bouwer, Herman.
Agricultural Research Service, Phoenix, Arizona.
American Society of Civil Engineers, Proceedings, Journal of Irrigation & Drainage Division, Vol. 95, No. IR4, Paper 6937, p 451-462, December 1969. 5 fig, 2 tab, 11 ref, append.

Descriptors: *Infiltration, *Soil water movement, *Irrigation, *Water spreading, Percolation, Runoff, Wetting, Hydraulic conductivity, Mathematical studies, Mathematical models.
Identifiers: Nonuniform soils.

A simplified procedure for calculating infiltration into soil of nonuniform water content or hydraulic conductivity, or both, is presented. The procedure is based on the Green and Ampt model of piston flow. Input data consist of the difference in water content before and after wetting, the hydraulic conductivity after wetting, and the water entry value of the soil. Techniques for measuring these parameters in the field are briefly described. The procedure is applied to calculate infiltration-time relationships for flood irrigation of a coarse-textured and a fine-textured soil, and to evaluate the effect of nonuniform inundation time on irrigation efficiency. The results show that the usual recommendation of allowing an inundation-time difference of not more than 25% of the time required for the desired amount of water to infiltrate into soil can give irrigation efficiencies of 90% or more. Thus, larger differences in inundation time can be allowed in practice, particularly if the hydraulic conductivity of the soil decreases with depth.

68-69:02G-031
MOVEMENT OF WATER AND SALT THROUGH A CLAY-WATER SYSTEM: EXPERIMENTAL VERIFICATION OF ONSAGER RECIPROCAL RELATION,
Letey, J., and Kemper, W. D.
California University, Riverside, Dept of Soil Physics.
Soil Science Society of America Proceedings, Vol. 33, No. 1, p 25-29, January-February 1969. 2 fig. 2 tab, 12 ref.

Descriptors: *Osmosis, *Saline water systems, *Soil water movement, *Osmotic pressure, Salinity.
Identifiers: *Onsager relation, Nonequilibrium thermodynamics.

Equations that describe the movement of solution and salt through a soil system in which there are both hydrostatic and osmotic pressure gradients are presented. These equations are: $J_v = -L_p \nabla P + L_{PD} \nabla\pi$, $J_D = L_{DP} \nabla P - L_D \nabla\pi$, and $J_s/C_s = (-L_p + L_{DP}) \nabla P + (-L_D + L_{PD}) \nabla\pi$ where J_v is the flux of solution, J_D the difference in velocity between water and salt, J_s is flux of salt, P is pressure, π is osmotic pressure, C_s is the average solute concentration, and L is phenomenological coefficients. The Onsager reciprocal relation states that $L_{PD} = L_{DP}$. This relation was found to be valid for a clay-water-salt system.

68-69:02G-032
SOIL WATER TRANSLOCATION IN A HIGH WATER TABLE AREA,
Benz, L. C., Willis, W. O., Sandoval, F. M. and Mickelson, R. H.
Agricultural Research Service, Mandan, North Dakota.
Water Resources Research, Vol. 4, No. 1, p 95-101, June 1968. 6 fig, 2 tab, 18 ref.

Descriptors: *Soil water, *Water table, *Soil temperature, *Confined water, *Translocation, Soil water movement, Specific yield, Saline soils, Mulching, Soil surfaces, Thermocline, Winter, Freezing, Soil profiles, Climatic data.
Identifiers: *Straw.

This paper reports results of a field experiment conducted to evaluate soil water, water table and soil temperature relationships in an area having a high water table, saline soil and artesian water. Soil surface treatments were straw cover and no cover--both without cropping. Soil water content increased during winter, depending on the surface treatment. Average water content of the soil profile increased more than the amount of water theoretically available on the basis of the specific yield and the corresponding water table drop. The additional water was apparently obtained from artesian groundwater. Changes in soil water content and water table depth were associated with soil temperature. As soil temperature decreased during the winter, the water table receded, and soil water content increased in the surface horizons by migration of water from the subsoil.

68-69:02G-033
THE ADAPTABILITY OF AN EXACT SOLUTION TO HORIZONTAL INFILTRATION,
Brutsaert, Wilfried.
Cornell University, Ithaca, New York.
Water Resources Research, Vol. 4, No. 4, p 785-789, August 1968. 3 fig, 12 ref, 1 append.

Descriptors: *Infiltration, Porous media, Seepage, Soil, Moisture, Permeability, Darcy's law, Capillary conductivity.
Identifiers: *Flow equations, Horizontal infiltration.

A mathematical solution is provided for the concentration-dependent diffusion equation. The equation is shown to be adaptable to the problem of horizontal infiltration, a phenomenon of one-dimensional flow in a partly saturated porous medium, by a suitable approximation of algebraic functions describing the moisture content capillary suction and the moisture content capillary conductivity relationships. One of the theoretical results that compares favorably with published experimental data gives the cumulative infiltration as a simple power function. Specific equations are derived and calculations are plotted.

68-69:02G-034
A STEADY-STATE METHOD FOR DETERMINING DIFFUSION COEFFICIENTS IN SOIL,
Tinker, P. B.
Oxford University (England), Soil Science Laboratory.
Journal of Soil Science, Vol. 20, No. 2, p 336-345, September 1969. 4 fig, 1 tab, 15 ref.

Descriptors: *Diffusivity, *Cations, *Soil chemistry, Ion transport, Soil chemical properties, Laboratory tests, Ion exchange, Electrolytes.
Identifiers: Soil diffusivity.

A simple method for determining steady-state diffusion coefficients of cations in soil with cation exchange papers as sources and sinks may be used at a range of moisture contents. It was tested on the inter-diffusion of Ca and Mg in a Coral Rag clay soil. Sectioning and analysis of the soil after the steady state was reached give a plot of composition with distance along the cell which was similar to the curved Ca-Mg exchange isotherm, and indicated that nearly all the flux was through the liquid phase. Values of the tortuosity factor could therefore be found. There were indications that bicarbonate ions were formed and increased the flux in some experiments. Transient-state diffusion coefficients were measured in the same experiments, and agreed fairly well with the steady-state results.

68-69:02G-035
THE EFFECT OF OSMOTIC PRESSURE GRADIENTS ON WATER MOVEMENT IN UNSATURATED SOIL,
Letey, J., Kemper, W. D., and Noonan, L.
California University, Riverside, Dept of Soil Physics.
Soil Science Society of America Proceedings, Vol. 33, No. 1, p 15-18, January-February 1969. 2 fig, 5 tab, 6 ref.

Descriptors: *Soil water movement, *Unsaturated flow, *Osmotic pressure, Osmosis, Clays, Salinity, Evaporation, Percolation, Diffusion, Flow measurement, Fluid mechanics, Permeability.
Identifiers: Concentration gradients.

Water movement, in response to osmotic pressure gradients, was measured in clay loam and sandy loam soils at soil water suctions from 0.08 to 15 bars. Movement in response to osmotic pressure gradients were compared to movement in response to hydraulic pressure gradients in the soil water suction range from 0.08 to 0.65 bars. At suction less than 0.5 bars, the amount of water moved by osmotic pressure gradients was generally less than 4% of the water moved by hydraulic gradients of equal magnitude.

68-69:02G-036
THE PERMEABILITY OF A POROUS MEDIUM DETERMINED FROM CERTAIN PROBABILITY LAWS FOR PORE SIZE DISTRIBUTION,
Brutsaert, Wilfried.
Cornell University, Ithaca, New York, School of Civil Engineering.
Water Resources Research, Vol. 4, No. 2, p 425-434, April 1968. 3 fig, 20 ref.

Descriptors: *Permeability, *Porous media, *Mathematical models, Soil moisture movement, Hydraulic models, Porosity, Dupuit-Forchheimer theory.
Identifiers: Series-parallel porosity model, Soil moisture-suction relationship, Porosity-permeability relationships.

An equation derived for the permeability of a porous medium based on the general principles of the series-parallel model contains a double integral which is solved for several continuous probability laws describing the distribution of the sizes of the interstices of the porous medium. The agreement between calculated results and available experimental data is satisfactory.

68-69:02G-037
PORE SIZE DISTRIBUTIONS AS MEASURED BY THE MERCURY INTRUSION METHOD AND THEIR USE IN PREDICTING PERMEABILITY,
Klock, G. O., Boersma, L., and DeBacker, L. W.
Oregon Agricultural Experiment Station, Corvallis.
Soil Science Society of America Proceedings, Vol. 33, No. 1, p 12-15, January-February 1969. 5 fig, 2 tab, 8 ref.

Descriptors: *Permeability, *Porous media, *Porosity, Equations, Regression analysis, Soil water movement, Permeameters, Capillary action, Saturated flow, Unsaturated flow.
Identifiers: Mercury intrusion porosimeter, Pore size distribution, Millington and Quirk equation.

Equations for predicting the permeability of porous media using pore size distribution are reviewed and a mercury intrusion method for obtaining pore size distribution information from samples is described. Calculated and measured permeability values of 35 glass bead and 28 sand samples were compared and agree closely. Permeabilities and pore size distributions of 54 systematically selected particle size classes of glass beads and sand were measured. Limits of the particle size classes ranged from 44-53 to 208-246 microns for the particle diameters. Millington and Quirk's equation was used to calculate the permeabilities. The calculated permeabilities agree with the measured values only when a correction factor is used.

68-69:02G-038
INDEPENDENT MEASUREMENT OF MATRIC AND OSMOTIC POTENTIAL OF SOIL WATER,
Oster, J. D., Rawlins, S. L., and Ingvalson, R. D.
Agricultural Research Service, Riverside, California.
Soil Science Society of America Proceedings, Vol. 33, No. 2, p 188-192, March-April 1969. 3 fig, 15 ref.

Descriptors: *Osmotic pressure, *Water chemistry, *Solutes, Moisture stress, Density, Soil water movement, Diffusion, Instrumentation, Tensiometers, Moisture tension.
Identifiers: Matric potential (Soil water), Salt exclusion, Psychrometry.

A technique is described that uses the operating principles of the thermocouple psychrometer and the porous plate apparatus to measure the matric and osmotic potentials of soil water without extraction of a significant amount of soil solution. The technique was tested on a Na-saturated Gila soil to which NaCl solutions with osmotic potentials of -1, -2, and -6 bars were added. The standard error of measurement of the soil water potential components was about 0.04 bar. The measured osmotic potentials of the soil were lower than those of the added solutions, which can be explained by salt exclusion although mineral dissolution could contribute to these results. The technique also permitted measurement of the partial molar volume of soil water with an accuracy of about 1%. Within this precision, the partial molar volume of soil water in this study was shown to be the same as that of pure water.

68-69:02G-039
DISPLACEMENT FRONT UNDER PONDED LEACHING,
Luthin, James N., Fernandez, Pedro, Masloc, Boris, Woerner, Jack, and Robinson, Frank.
California University, Davis, Dept of Water Science & Civil Engineering.
Journal of the Irrigation & Drainage Division, ASCE, Vol. 95, No. IR1, Proceedings Paper No. 6446, p 117-125, March 1969. 4 fig, 7 ref.

Descriptors: *Leaching, *Saline soils, *Drains, *Ponding, *Salts, Drainage, Irrigation water, Dispersion, Soil chemistry, Soil surfaces, Equations, Theoretical analysis, Analytical techniques.
Identifiers: *Displacement, Kirkham's equation.

Leaching of tile-drained soils by ponding water on the soil surface was examined both experimentally and theoretically. A method of analyzing movement of the displacement front was presented. The method was based on piston-type displacement of saline soil water by the added leaching water. In this initial analysis presence of precipitated salts, hydrostatic dispersion, and soil-chemical reactions were ignored. Experimental results obtained on a 15 by 6 by 3 foot tank showed satisfactory agreement to theoretical results obtained by solving Kirkham's equation for the ponded water case. Results indicated that ponded leaching was inefficient in removing salts midway between drains. Intermittant leaching by applying excessive amounts of irrigation water should be more efficient in controlling soil salinity.

68-69:02G-040
EFFECT OF SOIL PROFILES ON MOVEMENT OF WATER ON SUBSURFACE IRRIGATION,
Whitney, L. F., Muta, Kazuki, and Pira, E. S.
Massachusetts University, Amherst, Dept of Agricultural Engineering.
American Society of Agricultural Engineers, Transactions, Vol. 12, No. 1, p 98-99, January-February 1969. 7 fig, 1 tab, 6 ref.

Descriptors: *Subsurface irrigation, *Irrigation systems, *Interfaces, *Soil texture, *Soil profiles, Topsoil, Subsoil, Irrigation design, Soil water movement, Water pressure, Soil moisture.

Research was concerned with the reaction of water movement when water from a pressurized source reached the interface between soils of different textures. The beneficial effects of a layered soil profile for subsurface irrigation were demonstrated. This is particularly useful in subsurface irrigation of turf areas such as golf courses which are constructed to specifications. In irrigation or crops, however, the pipe network must be placed below tillage level. If the nozzles lie below the interface, it is unlikely that irrigation water will reach shallow-rooted crops. If the nozzles are above the interface, i.e., the top 16 inches of soil is homogeneous, then subsurface irrigation can be effectively employed.

68-69:02G-041
HEXADECANOL IN SOIL - ITS LOCATIONAL STABILITY AND INFLUENCE ON MODULUS OF RUPTURE,
Myhrman, Matts A., and Evans, D. D.
Arizona Agricultural Experiment Station, Tucson.
Soil Science Society of America, Proceedings, Vol. 33, No. 2, p 203-205, March-April 1969. 2 tab, 9 ref.

Descriptors: *Soil structure, *Soil amendments, *Hexadecanol, *Soil water movement, Soil aggregates, Soil texture, Soil treatment, Soil chemical properties, Soil physical properties, Permeability, Soil management, Soil strength.
Identifiers: Hexadecanol in soil.

Modulus of rupture was reduced 65% for a sandy loam soil and 57% for a silt loam soil by addition of 0.4% (by weight) dry powdered hexadecanol. Emulsified hexadecanol, powdered commercial tallow alcohol, and smaller dosages had less effect. Less than 2% of the C-14 tagged hexadecanol placed in a 1-cm thick layer of sandy soil moved under either saturated or unsaturated flow conditions. Movement probably took place in the form of small buoyant particles.

68-69:02G-042
SOIL MOISTURE AVAILABILITY FOR TRANSPIRATION,
Molz, F. J., Remson, Irwin, and Fungaroli, A. A.
Drexel Institute of Technology, Philadelphia, Pa.
Water Resources Research, Vol. 4, No. 6, p 1161-1169, December 1968. 4 fig, 1 tab, 16 ref.

Descriptors: *Soil water movement, *Evapotranspiration, Mathematical models, Diffusion, Unsaturated flow, Root zone, Soil moisture.

A differential equation is presented describing radial flow of soil moisture to a single vertical sink, for instance a root, in an infinite soil mass which is initially at a uniform moisture content. The relationship between moisture content and diffusivity for the soils studied may be represented by an exponential function. A numerical solution of the differential equation is used to determine the soil-moisture flux. The results show that for specific soils the decrease in soil moisture with time occurs mainly in the immediate vicinity of the sink. Moisture flux increases with initial moisture content but is essentially time independent. In natural systems the flux would probably decrease with time because of multiple root interference. At large soil-moisture contents, actual transpiration is limited by and equivalent to potential transpiration. At small soil-moisture contents, actual transpiration is limited by and equivalent to potential soil-moisture availability.

68-69:02G-043
SEEPAGE FROM CHANNELS THROUGH LAYERED POROUS MEDIUMS,
Jeppson, Roland W.
Utah State University, Logan.
Water Resources Research, Vol. 4, No. 2, p 435-445, April 1968. 7 fig, 5 ref.

Descriptors: *Seepage, *Channels, *Porous media, *Anisotropy, Mathematical models, Groundwater movement, Soil water movement, Surface-groundwater relationships, Approximation method, Digital computers.
Identifiers: Finite difference methods, Layered porous mediums.

Solutions to steady-state free surface problems of seepage from channels through porous mediums consisting of layers of different permeabilities are obtained by using the methods of finite differences. In the formulation of the problem, the magnitudes of the coordinates x and y are considered the dependent variables, and the potential function and the stream function are considered the independent variables. The method permits the shape of the interface that separates the two layers with different permeabilities to be specified. In the event that each layer is anisotropic, but with different ratios of horizontal to vertical permeabilities, the interface between the two layers is restricted to being horizontal. Example solutions are given for arbitrarily specified interfaces for both the case of seepage from a trapezoidal channel through homogeneous isotropic mediums in each layer (but of different permeabilities) and the case of anisotropic mediums in which the ratio of horizontal to vertical permeabilities is different for each layer.

68-69:02G-044
FIELD MEASUREMENT AND USE OF SOIL-WATER PROPERTIES,
Davidson, J. M., Stone, L. R., Nielson, D. R., and LaRue, M. E.
Oklahoma State University, Stillwater, Dept of Agronomy.
Paper No. H-43, presented at 50th Annual Meeting of American Geophysical Union, Washington, D.C., April 21-25, 1969. 33 p, 16 fig, 4 tab, 15 ref.

Descriptors: *Soil water movement, *Water properties, Soil profiles, Hydraulic conductivity, Soil texture, Soil types, Drainage effects, Drainage, Hysteresis, Darcy's law.
Identifiers: *Field measurement, Silty clay, Loamy sand.

Three soil profiles were used for measuring the relationships between the hydraulic conductivity and soil-water content. The physical properties of soils varied from homogeneous to heterogeneous and the surface texture ranged from loamy sand to silty clay. No measurable hysteresis was shown from the hydraulic conductivity values which were calculated from the drainage data. The Darcy's equation and other assumptions were used to predict the rate at which water drained from each soil profile.

68-69:02G-045
A SOLUTION FOR VERTICAL INFILTRATION INTO A DRY POROUS MEDIUM,
Brutsaert, Wilfried.
Cornell University, Ithaca, New York.
Water Resources Research, Vol. 4, No. 5, p 1031-1038, October 1968. 4 fig, 1 tab, 9 ref.

Descriptors: *Infiltration, *Unsaturated flow, *Porous media, *Mathematical studies, Soil moisture, Hydraulic conductivity, Diffusivity, Diffusion, Capillary conductivity, Darcy's law.
Identifiers: *Vertical infiltration.

An exact solution is presented for the second term of the series expansion of the numerical solution of the concentration-dependent diffusivity equation of J. R. Philip. The use of simple algebraic functions describing the water content-capillary suction and water content-capillary conductivity relationships of porous media makes the exact solution possible. Terms higher than second order are negligible because of fast convergence. Use of a previous solution for the first term of the expansion together with this solution for the second term is a satisfactory method of calculating vertical infiltration. The method was found to be in good agreement with results of infiltration experiments on Columbia silt loam.

68-69:02G-046
STEADY GRAVITATIONAL CONVECTION INDUCED BY A LINE SOURCE OF SALT IN A SOIL,
Raats, P. A. C.
Agricultural Research Service, Madison, Wisconsin.
Soil Science Society of America Proceedings, Vol. 33, No. 4, p 483-487, July-August 1969. 5 fig, 11 ref.

Descriptors: *Convection, *Diffusion, *Aqueous solutions, *Salts, Solutes, Saturated flow, Unsaturated flow, Soil water movement, Groundwater movement, Mass transfer, Ion transport, Hydraulic conductivity, Soil texture.
Identifiers: Salt solution convection.

A theoretical analysis of steady gravitational convection from a line source of salt in a saturated or in a uniformly partially saturated soil is presented. The flow pattern of the water-solute mixture and the distribution of the salt are shown to depend upon the source strength of the line source, the effective mass diffusion coefficient of the salt in the soil, the hydraulic conductivity of the soil, and a parameter describing the increase in density due to the added solute. Qualitatively, the analysis agrees with experimental observations. Theory and experiment both indicate that gravitational convection can be significant only if the hydraulic conductivity is large, which may be the case if the soil is coarse textured and the water content is not too small.

68-69:02G-047
PLANNING AND INTERPRETING SOIL PERMEABILITY MEASUREMENTS,
Bouwer, Herman.
Agricultural Research Service, Phoenix, Arizona.
American Society of Civil Engineers, Proceedings, Journal of the Irrigation & Drainage Division, Vol. 95, No. IR3, Paper No. 6775, p 391-402, September 1969. 4 fig, 3 tab, 19 ref, append.

Descriptors: *Permeability, *Soil water movement, *Measurement, *Planning, Instrumentation, Drainage engineering, Infiltration, Hydraulic conductivity, Irrigation design.
Identifiers: Soil permeability measurement.

Field techniques for measuring soil hydraulic conductivity (below the water table as well as above, or in the absence of, a water table) are considered. In selecting a technique for a given situation, care should be taken that the soil region and dominant flow direction in the system to be analyzed or predicted are as closely duplicated by the technique as possible. If the soil region covered by an individual measurement is small compared to that of the actual system, measurements at different depths and locations are necessary. The resulting values will seldom if ever be uniform and simplification to manageable media may be required. The average hydraulic conductivity of a randomly heterogeneous medium must lie between the harmonic and the arithmetic mean. Studies with a resistance network analog show that this avarage hydraulic conductivity is best estimated by the geometric mean.

68-69:02G-048
EFFECTS OF PETROLEUM MULCH ON SOIL WATER CONTENT AND SOIL TEMPERATURE,
Kowsar, Ahang, Boersma, L., and Jarman, G. D.
Oregon State University, Corvallis, Dept of Soils.
Soil Science Society of America Proceedings, Vol. 33, No. 5, p 783-786, September-October 1969. 6 fig, 1 tab, 14 ref.

Descriptors: *Soil management, *Mulching, *Soil moisture, *Soil temperature, Evaporation control, Soil conservation, Infrared radiation, Soil physical properties, Water loss, Storage capacity, Soil water movement.
Identifiers: Petroleum mulch.

Soil temperature and soil water content were measured at 2-hour intervals in mulched and unmulched chehalis silty clay loam subjected to a diurnal temperature cycle. At the time the soil temperatures attained their maximum value at a depth of 1 cm, the mulch-covered soil was 5C warmer than the bare soil; at all other times the difference in temperature between bare and mulched soil was smaller. In the upper 1 cm of mulched soil, water was lost but the soil gained water at depths where seedlings are normally placed. It was concluded that the petroleum mulch improved soil water and soil temperature conditions.

68-69:02G-049
COMPUTATION OF THE DESALINIZATION OF SALINE SOILS UNDERLAIN BY A WATER-PERMEABLE LAYER,
Savel'yeva, R. V., and Baron, V. A.
Soviet Hydrology: Selected Papers, Issue No. 1, p 94-98, 1969. 1 fig, 7 ref.
Translated from Izvestiya Akad nauk Uzb SSR, ser. tekh nauk No. 3, p 39-43, 1969.

Descriptors: *Saline soils, *Leaching, *Land management, Diffusion, Ion transport, Mass transfer, Groundwater movement, Soil water movement, Permeability, Heat transfer, Convection, Salinity, Water quality, Soil chemical properties.
Identifiers: *Soil desalination, USSR.

The salt regime of soil water forms under the effect of molecular diffusion, sorption, filtration, and thermal and pressure diffusion. The gradients of thermal and pressure diffusion are 4-5 orders of magnitude lower than the gradients of the concentration of matter. Knowing the initial salinization profile, the leaching rate (magnitude of filtration flow), porosity, the coefficient of convective diffusion, the thickness of the fine-earth mantle, and salt concentration of the leaching water, the salt regime of soils may be calculated.

68-69:02G-050
LABORATORY METHOD FOR SUPPLYING MOISTURE UNIFORMLY TO SOIL BY CONDENSATION,
Trent, D. S., Larson, M. B., Shen, C. Y., Postlewaite, J. E., and Wolfe, J. W.
Battelle Memorial Institute, Richland, Washington.
American Society of Agricultural Engineers, Transactions, Vol. 11, No. 4, p 519-522, July-August 1968. 6 fig, 5 ref.

Descriptors: *Soil moisture, *Condensation, *Air circulation, *Thermal conductivity, *Temperature control, Temperature, Flow rates, Irrigation, Plant physiology, Equations, Instrumentation.

The three experimental objectives were: (1) to determine if it were theoretically possible to uniformly condense moisture in a cooled soil test bed from the flow of water-saturated air, (2) to discover a practical means of controlling such moisture deposition, and (3) to decide if the technique were a suitable instrument to aid laboratory research in plant physiology. Theory demonstrates that it is probably impossible, and certainly impractical, to obtain perfect moisture uniformity. However, the greatest uniformity can be achieved by minimum variation in temperature. To control this temperature distribution, pins made from material having a higher thermal conductivity than the porous bed are placed in the bed parallel to the flow. The pins, attached to a cooling plate, appear to increase significantly the effective conductivity of the bed. The experiment indicates that optimum uniform moisture deposition is achieved by adjusting the flow rate until the midpoint temperature is within the theoretically allowed variation.

68-69:02G-051
WATER MOVEMENT IN DRY SOILS I. PHYSICAL FACTORS AFFECTING SORPTION OF WATER BY DRY SOIL,
Rose, D. A.
Rothamsted Experimental Station, Harpenden, Herts, England.
Journal of Soil Science, Vol. 19, No. 1, p 81-93, March 1968. 9 fig, 4 tab.

Descriptors: *Soil water movement, Soil moisture, Arid lands, Atmosphere, Diffusivity, *Temperature, Salinity, Evaporation control, Environmental effects, *Sorption, Water vapor, Water transfer, Equations, Soil aggregates, *Moisture content, *Soil physics.

The paper considered effects of various soil physical conditions on uptake of water from a moist atmosphere by a soil sufficiently dry that both liquid and vapor components of flow may be important. Water extraction by growing plants will dry soil in the root zone to c pF 4.2 and natural evaporation can dry surface layers to c pF 6 or even drier in arid regions. Theoretical aspects of water movement in dry soils were explained using 5 equations. Sorption took place in soil columns that were in a turbulent atmosphere at constant temperature and relative humidity. Diffusivity rose to a maximum and then fell as water content increased. Effects of environment and management were studied in the areas of temperature, pressure, porosity, organic manure, aggregate size, still atmosphere, mulching, salinity, evaporation suppressants, ignition and degradation of structure. In the dry soils tested, water movement was a mixture of liquid and vapor transfer and the relative importance of the two modes of flow varied from soil to soil. The data showed the effect of pre-treatment on diffusivity and sorptivity, but there was no experience yet to indicate what changes might have agricultural significance.

68-69:02G-052
CONDUCTIVITY INSTRUMENTATION FOR IN SITU MEASUREMENT OF SOIL SALINITY,
Enfield, C. G., and Evans, D. D.
Burr-Brown Research Corp., Tucson, Arizona.
Soil Science Society of America Proceedings, Vol. 33, No. 5, p 787-789, September-October 1969. 8 fig, 1 tab, 5 ref.

Descriptors: *Electrical conductance, *Instrumentation, *Salinity, *Soil chemical properties, Soil physical properties, Soil temperature, Aqueous solutions.
Identifiers: Soil salinity meters.

A transducer has been developed which is capable of assessing, in situ, the electrical conductivity of soil water. The transducer is constructed of porous glass with platinum electrodes and operates over the entire field moisture range. The transducer is accurate to within 10% when measured with an associated solid state meter in a conductivity range of 1-20 millimhos/cm at 25C and a temperature range of 5-45C. Typically, the time required to achieve 63% of equilibrium response, in aqueous solutions, is less than 2 hours.

68-69:02G-053
QUICK-RETURN SUBSURFACE FLOW,
Jamieson, D. G., and Amerman, C. R.
USDA Hydrograph Laboratory, Beltsville, Maryland.
Journal of Hydrology, Vol. 8, No. 2, p 122-136, June 1969. 1 tab, 16 ref.

Descriptors: *Soil water movement, *Subsurface runoff, *Routing, *Surface-groundwater relationships, Water storage, Model studies, Mathematical models, Simulation analysis, Hydrograph analysis, Systems analysis, Infiltration, Overland flow, Percolation.
Identifiers: Quick-return subsurface flow.

One of the least understood of all hydrologic problems is that of lateral flow in the soil's upper horizons. The nature and quantity involved in this quick-return flow are unknown and have to be inferred from the shape of the observed hydrograph. An attempt has been made to mathematically simulate the flow phenomenon using rainfall as input and a system of interconnected, nonlinear reservoirs as the operator.

68-69:02G-054
ACTIVATION ANALYSIS: A NEW TECHNIQUE FOR SOIL MOVEMENT STUDIES,
Beer, Craig E., and Hendrickson, R. A.
Iowa State University, Ames.
Agricultural Engineering, Vol. 50, No. 3, p 144-145, March 1969. 1 fig.

Descriptors: Soils, *Radioisotopes, *Tracers, *Sediment transport, *Isotopes, Movement, Gamma rays, Irradiation, *Sediment distribution, Laboratory tests, Hydrologic cycle, Hydrology.
Identifiers: *Activation analysis, *Lanthanum.

Laboratory test results show that lanthanum used as a tracer element in activation analysis permits detailed study of elements within a hydrologic cycle. In activation analysis, certain elements are irradiated with nuclear particles to produce radioisotopes. By counting the rate of disintegration of these radioisotopes, a quantitative evaluation of the amount of the original element present is possible. A soil-lanthanum test sample mixture was irradiated with thermal neutrons. Analysis showed that over 90% of the lanthanum adhered to the soil. The ultimate objective is to use lanthanum as a tracer element in activation analysis to study the origin and movement of sediments in certain phases of the hydrologic cycle. The procedure will involve mixing lanthanum in soil on a larger scale to produce a seeding batch. The treated soil will then be placed in the field at predetermined points. Sampling will be done immediately after seeding and at points along the flow path. The apparent ability of lanthanum to adhere to inert particles can make its use virtually unlimited.

68-69:02G-055
MISCIBLE DISPLACEMENT IN AN UNSATURATED GLASS BEAD MEDIUM,
Krupp, H. K., and Elrick, D. E.
Guelph University, Ontario (Canada).
Water Resources Research, Vol. 4, No. 4, p 809-815, August 1968. 6 fig, 1 tab, 12 ref.

Descriptors: *Porous media, *Soil water movement, *Mixing, Water structure, Pore pressure, Model studies, Tracers.
Identifiers: *Miscible displacement, *Chemical transport, Unsaturated medium, Pore volumes.

In order to analyze the mixing behavior of solutes in a porous medium over a wide range of water contents, a series of miscible displacement experiments was conducted in an unsaturated glass bead medium, at constant average water content during each displacement. Variation in the form of the breakthrough curve with decreasing water content was not large and was not related in a simple way to the water content; however, there was a consistent shift of the breakthrough curve to the left of the relative concentration value of 0.5 and 1 pore volume and a long tail or slow approach to the final relative concentration of 1.0. Some of these effects may be attributed to the presence of 'stagnant' liquid in the pores. Tbe earliest appearance of tracer in the effluent was observed at a saturation fraction in the range of 0.54 to 0.56. This behavior is largely the result of disorder in the sample liquid. Both filled and partially filled pores and pore sequences were present in different amounts and mixing was not simply related to moisture content. At the higher water contents, flow in filled pores was dominant, whereas at lower water contents flow in partially filled pores and surface films dominated the displacement.

68-69:02G-056
THEORY AND EXPERIMENT IN CANAL SEEPAGE ESTIMATION USING RADIOISOTOPES,
Krishnamurthy, K., and Rao, S. M.
Bhabha Atomic Research Center, Bombay (India).
Journal of Hydrology, Vol. 9, No. 3, p 277-293, November 1969. 6 fig, 2 tab, 14 ref.

Descriptors: *Canal seepage, *Radioactivity techniques, *Tracers, *Tracking techniques, *Reviews, On-site investigations, Seepage, Soil water movement, Groundwater movement, Mathematical studies, Mathematical models.
Identifiers: *India, Ganga Canal.

A brief survey of the many existing computational and experimental methods in estimating seepage losses from unlined canals is given. A new method is suggested in which the filtration velocity of seepage is measured using radioisotopes. The seepage rate is then computed from the knowledge of the phreatic curve and Numerov's theoretical formula for laterally spreading seepages from unlined canals. A practical application of the procedure to estimate seepage losses from Ganga Canal near Roorkee, India is also described.

68-69:02G-057
STEADY-STATE POTENTIAL AND MOISTURE-PROFILES IN LAYERED POROUS MEDIA,
Poulovassilis, A.
Athens School of Agriculture, Athens (Greece), Dept of Agricultural Chemistry.
Soil Science, Vol. 107, No. 1, p 47-52, January 1969. 12 fig, 10 ref.

Descriptors: *Soil moisture, *Porous media, *Moisture tension, Potential flow.
Identifiers: *Moisture profiles,*Layered soil.

The shape of the steady-state potential and moisture profiles in a layered porous column has been examined both theoretically and experimentally. It has been shown that the general shape of such a profile depends upon the layer sequence and the suction value prevailing at the junction which depends not only upon the magnitude of the flow rate, but also for the first junction upon its position with respect to the water table and for the subsequent ones upon the width of the layers.

68-69:02G-058
PERMEABILITY OF ORTHOTROPIC POROUS MEDIUMS,
Szabo, B. A.
New York State University, Buffalo.
Water Resources Research, Vol. 4, No. 4, p 801-808, August 1968. 4 fig, 1 tab, 13 ref.
(see 68-69:02F-046)

68-69:02G-059
INFILTRATION AS INFLUENCED BY TILLAGE-INDUCED RANDOM ROUGHNESS AND PORE SPACE,
Burwell, R. E., and Larson, W. E.
Agricultural Research Service, Morris, Minnesota.
Soil Science Society of America Proceedings, Vol. 33, No. 3, p 449-452, May-June 1969. 3 fig, 3 tab, 9 ref.

Descriptors: *Infiltration, *Rainfall-runoff relationships, *Soil erosion, *Cultivation, Soil texture, Runoff, Soil physical properties, Permeability, Porosity, Soil conservation, Soil mechanics, Soil stabilization, Surface runoff, Erosion control.
Identifiers: Erosion index, Random roughness.

During simulated rainfall, increases in tillage-induced random roughness and pores space increased water infiltration before runoff started but did not significantly influence infiltration throughout a 5-cm runoff period. Random roughness provided a greater accounting of infiltration variation among tillage treatments to initial runoff than did total pore volume of the tilled layer. Freshly turnplowed alfalfa-bromegrass sod on Barnes loam and Nicollet sandy clay loam soil provided random roughness and pore space conditions that could accommodate without 'failure' the major portion of rainfall energy (as evidenced by EI) expected in west central and southwestern Minnesota during the first 2 months following row crop planting. This is the critical runoff-erosion period in the Corn Belt.

68-69:02G-060
SOIL-WATER MOVEMENT IN RESPONSE TO IMPOSED TEMPERATURE GRADIENTS,
Cassel, D. K., Nielsen, D. R., and Biggar, J. W.
California University, Davis, Dept of Water Science and Engineering.
Soil Science Society of America Proceedings, Vol. 33, No. 4, p 493-500, July-August 1969. 10 fig, 4 tab, 21 ref, 1 append.

Descriptors: *Soil water movement, *Convection, *Water temperature, *Thermodynamic behavior, *Diffusion, Mass transfer, Diffusivity, Water vapor, Thermodynamics, Unsaturated flow.
Identifiers: Temperature gradient, Ficks law.

Redistribution of soil water within insulated, uniformly packed, horizontal samples of unsaturated Columbia fine sandy loam at several soil-water contents was studied in response to imposed temperature gradients ranging from 0.5 to 1.0C/cm. Soil bulk density and initial, transient, and final soil-water-content distributions were determined each 0.5-cm along the column by gamma-radiation attenuation. Initial, transient, and final soil temperature distributions were monitored by glass-encased thermistors at 2-cm intervals-both at the center and 0.3 cm from the column wall. Apparent thermal and isothermal soil-water diffusivity values were calculated using transient water content data. The observed net water flux was found to increase with decreasing water content. For Columbia soil the observed mean net water flux across 1-cm sections of the soil showed acceptable agreement with that predicted by the theory of Philip and deVries; Fick's law and the modified Taylor-Cary irreversible thermodynamic equation both underpredicted the observed fluxes.

68-69:02G-061
THE EFFECT OF THE CONCENTRATION AND MOVEMENT OF SOLUTIONS ON THE SWELLING, DISPERSION, AND MOVEMENT OF CLAY IN SALINE AND ALKALI SOILS,
Rowell, D. L., Payne, D., and Ahmad, N.
Reading University (England), Dept of Soil Science.
Journal of Soil Science, Vol. 20, No. 1, p 176-188, March 1969. 6 fig, 14 ref.

Descriptors: *Expansive soils, *Ion exchange, *Water chemistry, *Alkaline soils, *Saline soils, Permeability, Hydraulic conductivity, Expansive clays, Impervious soils, Electrolytes, Montmorillonite, Adsorption, Laboratory tests, Soil mechanics, Dispersion, Diffusion.
Identifiers: Swelling clays, Swelling soils.

Changes in permeability of a soil containing montmorillonite, and the swelling of orientated aggregates of extracted clay have been found and compared with the concentrations at which aggregates dispersed in stationary solutions, and the concentrations at which soil suspensions dispersed when shaken. The results indicate that (a) permeability begins to decrease at the same concentrations as the clay begins to swell, (b) the changes in permeability are directly controlled by the swelling of clay until clay dispersion and movement begins, (c) the concentration at which clay disperses depends on the mechanical stress applied, (d) when small mechanical stresses are applied, the proportion of the clay which swells and disperses depends directly on the exchangeable sodium percentage, and (e) large mechanical stresses may disperse most of the clay even at low exchangeable sodium percentages.

68-69:02G-062
AN ANALYSIS OF THE VERTICAL INFILTRATION OF WATER INTO SOIL COLUMNS,
Thames, John L., and Evans, D. D.
Arizona University, Tucson, Dept of Agricultural Chemistry.
Water Resources Research, Vol. 4, No. 4, p 817-828, August 1968. 10 fig, 1 tab, 8 ref.

Descriptors: *Infiltration, *Soil, *Porous media, *Soil density, Regression analysis, Flow characteristics.
Identifiers: *Flux equations, Vertical water infiltration.

To investigate the behavior of soil water movement during infiltration and thereby determine the applicability of flux equations involving soil water content gradients as the apparent driving force, an experimental study was made of vertical infiltration of water. Sandy loam and silt loam soil materials were used as experimental media. Water was allowed to enter air-dry columns of soil at a small constant suction, and the subsequent distribution was followed with a gamma radiation attenuation device. An analytical expression of water content as a function of depth and time was obtained by multiple regression analysis, from which it was possible to determine the instantaneous flux and the water concentration gradient at given water contents. Nonlinearity at low water gradient was evidenced for both soils throughout a wide range of water contents; the magnitude and direction of departure from linearity were similar for both soils. A new empirical flow equation was obtained by modifying the diffusivity equation for unsaturated flow. Under this modification, derived by raising the water-content gradient to a power greater than unity, the parameter analogous to soil-water diffusivity becomes a function of both water content and water-content gradient.

68-69:02G-063
INFILTRATION OF WATER INTO SOILS AS INFLUENCED BY SURFACE SEAL DEVELOPMENT,
Edwards, W. M., and Larson, W. E.
Agricultural Research Service, Coshocton, Ohio.
Transactions of the American Society of Agricultural Engineers, Vol. 12, No. 4, p 463-465, 1969. 4 fig, 1 tab, 11 ref.

Descriptors: *Infiltration, *Penetration, Soil surfaces, Unsaturated flow, Hydraulic conductivity, *Impact (rainfall), *Raindrops, Soil water, Numerical analysis, Model studies.
Identifiers: Ida silt loam.

A numerical solution of the water-flow equation for estimating infiltration into a homogenous soil was used to describe the effect of a developing surface seal on infiltration of water. Saturated conductivity for the surface 0.5 cm of six Ida silt loams was determined as a function of length of exposure to simulated rainfall and used in the computer solution to describe infiltration into a soil, the surface of which is exposed to raindrop impact. Estimated two-hour infiltration was reduced by as much as 50 percent by surface sealing. The suction gradient through the surface seal increased with decreasing conductivity of the seal and with increasing conductivity of the layer below the seal. Low conductivities of saturated surface seals were partially offset by strong suction gradients which move water through the surface at rates considerably higher than the saturated conductivities of the seals.

68-69:02G-064
MOISTURE PROFILES IN LAYERED POROUS MATERIALS DURING STEADY-STATE INFILTRATION,
Bybordi, M.
Cambridge University, Massachusetts, School of Agriculture.
Soil Science, Vol. 105, No. 6, p 379-383, June 1968. 3 fig, 8 ref.

Descriptors: *Infiltration, *Groundwater movement, Soil moisture, Soil physical properties, Hydraulic conductivity, *Darcy's law, Pores, Porous media, Saturated flow.
Identifiers: *Moisture profiles, *Layered porous material.

A knowledge of the dependence of the hydraulic conductivity and of the pore water suction of a porous material upon the degree of saturation permits an application of Darcy's law to the calculation of the moisture profile in a variety of situations. This paper investigates the applicability of the procedure to the situation where the soil profile is layered, the pore space geometry which determines the dependence of hydraulic conductivity upon moisture content being a function of distance above the water table. Saturated and unsaturated hydraulic conductivities were established for sand of less than 60 mesh and for sand of 44-60 mesh. Experiments were run in 200 cm column with 100 cm of coarse sand under 100 cm of fine sand to establish a steady state moisture profile. Good agreement was found between the theoretical moisture profiles and the experimental profiles for a range of flow rates.

68-69:02G-065
AN ESTIMATION OF SORPTIVITY FOR INFILTRATION STUDIES FROM MOISTURE MOMENT CONSIDERATIONS,
Youngs, E. G.
Agricultural Research Council, Cambridge, England, Unit of Soil Physics.
Soil Science, Vol. 106, No. 3, p 157-163, September 1968. 4 fig, 1 tab, 9 ref.

Descriptors: *Infiltration, Ground water movement, *Soil moisture, *Hydraulic conductivity, Porous media, Moisture content, Moisture tension.
Identifiers: *Sorptivity, *Philip's equation, *Moment.

Since Philip's infiltration theory is based on more general properties than the initial moisture content of the porous material, sorptivity has been calculated from a knowledge of the hydraulic conductivity and suction relationships with moisture content for a given porous material. The equations for the analysis of water uptake by the moment method are developed for the horizontal and vertical infiltration cases. Using the Boltzmann transformation $\lambda = xt^{-1/2}$, the moment of the horizontal case is transformed and a theoretical value for sorptivity based on moisture content is derived. Theoretical values and experimental values for A were compared with satisfactory agreement. For the vertical infiltration case, the value for the coefficient B in the equation $i = A\sqrt{t} + Bt$ was estimated by comparing it with the infiltration equation of Green and Ampt. The author feels that the constant A can be obtained using the equation for A in the horizontal case and the constant B can be put equal to $2/3K_o$. The theoretical and experimental values for cumulative infiltration show good agreement for low values of t for the material tested. However, results for large t indicate that care is required in choosing the constant B and using Philip's equation for vertical infiltration studies. The results of an experimental investigation of the rate of change of the moment of moisture during water uptake by horizontal columns is given.

68-69:02G-066
DETERMINING WATER CONTENT OF DIFFERENT SOILS BY THE NEUTRON METHOD,
Luebs, R. E., Brown, M. J., and Laag, A. E.
Agricultural Research Service, Riverside, California.
Soil Science, Vol. 106, No. 3, p 207-212, 1968. 4 fig, 2 tab, 8 ref.

Descriptors: *Soil water, *Measurements, *Moisture content, Neutron meters.
Identifiers: Neutron method.

The relationship between count rate obtained with the neutron method and soil water content below the 30-cm depth differed for several soils. The maximum difference observed was equivalent to 4.4 percent water by volume or approximately 0.8 surface cm for a 15-cm depth increment. Curve slopes were similar for the soils investigated. Higher count rates were associated with a higher bulk density of the soil. Soils for which the counting rate difference was the greatest differed 0.3 g/cc in bulk density. Counting rates for soils of the same series were closely related to bulk density in contrast to the lack of a relationship among series. The most accurate soil water determinations, by the neutron method, require calibration for the soil in question including the consideration of bulk density changes in the profile. A high linear correlation between count rate and soil water content was obtained for the 0- to 15-cm layer. Repeated field determinations of soil water content in the undisturbed 0- to 15-cm layer can be satisfactorily obtained by calibrating for the particular soil and carefully controlling depth of measurement.

68-69:02G-067
EVALUATION OF DYES FOR TRACING WATER MOVEMENT IN ACID SOILS,
Corey, J. C.
Savannah River Laboratory, Aiken, South Carolina.
Soil Science, Vol. 106, No. 3, p 182-187, 1968. 3 fig, 3 tab, 9 ref.

Descriptors: *Acidic soils, *Tracers, Path of Pollutants, Evaluation.
Identifiers: Erio Floxine 2G (Acid Red 1), Crimson Gr Hi Cone (Acid Red 14), Alphazurine B Cone (Acid Blue 26).

Suitable nonfluorescent dyes for illustrating streamlines in kaolinitic, acid soils are Erio Flxoine 2G Supra (Acid Red 1), Crimson Gr Hi Cone (Acid Red 14), and Alphazurine B Cone (Acid Blue 26). None of these dyes moved as rapidly as water. Dyes with two sulfonic acid groups moved more readily through acid soils than did dyes with one sulfonic acid group. Dyes were used to trace divergence of streamlines around coarse gravel lenses during unsaturated flow in finely textured soil.

68-69:02G-068
IN SITU DETERMINATION OF PHYSICAL PROPERTIES OF THE SURFACE LAYER OF FIELD SOILS,
De Vries, J.
British Columbia University, Vancouver, Canada, Dept of Soil Science.
Soil Science Society of America Proceedings, Vol. 33, No. 3, p 349-353, May-June 1969.
9 fig, 3 tab, 5 ref.

Descriptors: *Soil water, Saturated soils, Physical properties, Soil surfaces, *Gamma rays.
Identifiers: Random emission, Collimated beam, Water retention curve.

A set of gamma ray attenuation vs. soil water matric potential data was obtained in situ by saturating an undisturbed block of soil, and by lowering the water level in steps and measuring the count rate through the soil and the corresponding water matric potential at each step. Relative water contents were calculated from the count rates by use of a rational calibration equation. The corresponding matric potential was measured with a low impedance tensiometer . A partial water retention curve was plotted from these data, from which in turn the air intrusion value and the aeration porosity were inferred. It was shown that collimation is essential for measurements within the 1-cm thick surface layer, but it is not required for measurements within the bulk of a layered system. With a 5-mc cesium-137 source, a collimated beam and a 4-min counting time, the precision was ± 0.6% water content due only to errors associated with random emission. There was good agreement between a partial water retention curve obtained in situ and the one obtained with an outflow method in the laboratory.

68-69:02G-069
DEGRADATION OF WATER QUALITY IN IRRIGATION RETURN FLOWS,
Law, J. P., Jr., Davidson, J. M., and Read, L. W.
Robert S. Kerr Water Research Center, Ada, Oklahoma.
Oklahoma State University, Agricultural Experiment Station Bulletin B-684, October 1970. 26 p, 7 fig, 6 tab, 27 ref, 1 append.

Descriptors: *Water quality, *Return flow, *Irrigation water, *Salinity, Nitrates, Nitrogen, Fertilizers, Border irrigation, Furrow irrigation, Alkalinity, Sulfates, Calcium, Magnesium, Sodium, Ammonium compounds.
Identifiers: Tillman clay loam, Hollister clay loam, Total dissolved solids.

Research has been conducted concerning regional effects of irrigation return flows, but few results are available for evaluation of the quality characteristics of return flow from individual field plots. The locale selected had been in cotton production for 15 years prior to initiation of the study during which time uniform treatments of irrigation water, pesticides and fertilizers had been applied. Soil samples were taken at 4 locations in 3 rows to a depth of 96 inches prior to the first irrigation and then repeated after the irrigation season to establish the salinity changes within the soil profile. Samples of the surface flows in the field along with soil moisture extract samples at different depths were taken throughout the study. Data indicate a 20% degradation in water quality in the surface flows and a five to eight fold increase in salinity in the percolating water. The drainage waters from the irrigation area were sufficiently degraded to adversely affect both surface and groundwater resources in the area.

68-69:02G-070
INFILTRATION OF WATER INTO SOILS AS INFLUENCED BY SURFACE SEAL DEVELOPMENT,
Edwards, W. M., and Larson, W. E.
Agricultural Research Service, Coshocton, Ohio.
Transactions of the American Society of Agricultural Engineers, Vol. 12, No. 4, p 463-465, 1969. 4 fig, 1 tab, 11 ref.

Descriptors: *Infiltration, *Penetration, Soil surfaces, Unsaturated flow, Hydraulic conductivity, *Impact (Rainfall), *Raindrops, Soil water, Numerical analysis, Model studies.
Identifiers: Ida silt loam.

A numerical solution of the water-flow equation for estimating infiltration into a homogenous soil was used to describe the effect of a developing surface seal on infiltration of water. Saturated conductivity for the surface 0.5 cm of six Ida silt loams was determined as a function of length of exposure to simulated rainfall and used in the computer solution to describe infiltration into a soil, the surface of which is exposed to raindrop impact. Estimated two-hour infiltration was reduced by as much as 50 percent by surface sealing. The suction gradient through the surface seal increased with decreasing conductivity of the seal and with increasing conductivity of the layer below the seal. Low conductivities of saturated surface seals were partially offset by strong suction gradients which move water through the surface at rates condiderably higher than the saturated conductivities of the seals.

68-69:02G-071
EFFECTS OF TILLAGE, NO TILLAGE, AND MULCH ON SOIL WATER AND PLANT GROWTH,
Jones, J. N., Jr., Moody, J. E., Lillard, J. H.
Agricultural Research Service, Blacksburg, Virginia.
Agronomy Journal, Vol. 61, No. 5, p 719-721, September-October, 1969. 2 fig, 3 tab, 7 ref.
(See 68-69:03F-027)

68-69:02G-074
CHROMATOGRAPHIC MODEL FOR PREDICTING PESTICIDE MIGRATION IN SOILS,
King, P. H., and McCarty, P. L.
Virginia Polytechnic Institute and Stanford University.
(See 68-69:05A-007)

SECTION VI

WATER CYCLE - WATER IN PLANTS (Group 02I)

68-69:02I-001
EVALUATION OF COTTON RESPONSE TO RATES, SOURCES, AND TIMING OF NITROGEN APPLICATION BY PETIOLE ANALYSIS,
Amer, F., and Abuamin, H.
University of Alexandria, United Arab Republic, Dept of Soils.
Agronomy Journal, Vol. 61, No. 4, p 635-637, July-August 1969. 1 fig, 1 tab, 12 ref.

Descriptors: *Ammonium compound, Calcium, Nitrogen, Cotton.
Identifiers: Availability coefficient.

Three experiments were conducted on a calcareous clay loam soil to determine the relationship between nitrate-nitrogen content of cotton (Gossypium barbadense) petiole and yield; and to employ the petiole analysis technique for evaluation of calcium nitrate, ammonium nitrate, and urea as N sources and evaluation of timing of N application. Increase in cotton yield associated with unit increment of petiole nitrate was proportional to the decrement from the maximum and the data were fitted to the exponential equation of Spillman. Cotton yield was not affected by N source and time of application, but petiole nitrate was sensitive to both. Calcium nitrate was the best fertilizer and the availability coefficients of N in ammonium nitrate were 0.714 and 0.511, respectively. Splitting the applied N in thirds proved superior to a split into two applications or to a single total application, and the availability coefficients ratios were 20.889, and 0.566, respectively.

68-69:02I-002
GROWTH, YIELD, AND YIELD COMPONENTS OF SAFFLOWER AS AFFECTED BY IRRIGATION REGIMES,
Erie, L. J., and French, O. F.
U.S. Water Conservation Laboratory, Phoenix, Arizona.
Agronomy Journal, Vol. 61, No. 1, p 111-113, January-February 1969. 1 fig, 5 tab.

Descriptors: *Consumptive use, *Irrigation, Available water, Soil moisture, Seeds.
Identifiers: *Frio safflower, Yield per unit of water, Irrigation management.

Three to nine irrigations were given in eight irrigation treatments of fall-planted Frio safflower. Irrigations were given when 60 or 72% of the available water in the top 120 cm of soil was depleted. Five different irrigation cutoff dates were compounded on the soil moisture depletion treatments, ranging from 3 weeks before first blossoming until harvest. The yield of safflower seed increased with each increment of irrigation water to a maximum yield obtained with seven irrigations given until the last blossoms opened (3,961 kg/ha). Consumptive use for this treatment was 107 cm of water. When the last irrigation was given at the first flowering data, seed yield was reduced over 900 kg/ha. Giving the last irrigation about 10 days before blossoming reduced yields nearly one-half. Weight per seed, oil content, and seeds per head also increased with irrigations up to seven, and the percentage of hollow seed decreased. The seven-irrigation regime also resulted in the greatest yield per centimeter of water used by the plant. The level of moisture depletion before irrigation had no significant effect on any of the factors studied.

68-69:02I-003
NITROGEN CONTENT OF GRAIN AS INFLUENCED BY WATER SUPPLIED TO THE PLANT.
Stone, J. F., and Tucker, B. B.
Oklahoma State University, Stillwater, Dept of Agronomy.
Agronomy Journal, Vol. 61, No. 1, p 76-78, January-February 1969. 4 fig, 2 tab, 4 ref.

Descriptors: *Crop production, *Fertilization, Wheat, Sorghum, Irrigation, *Nitrogen, *Protein, Plant physiology.
Identifiers: *Grain quality.

Results of independent studies involving wheat (Triticum aestivum L.) and grain sorghum (Sorghum bicolor (L.) Moench) indicate that a linear relationship exists between nitrogen fraction in the grain and the quantity of water applied to the soil surface

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just prior to and through vegetative growth of the plant. The effect was noted consistently in studies in Oklahoma and Texas. The designated purpose of these studies was to determine effects of fertilizer amounts and irrigation amount and timing on the production of crops. The studies were conducted at widely separated locations over eight growing seasons. The effect was noted by chance during evaluation of one of the studies and was found to exist in data found in the literature and in data from other studies of the authors.

68-69:02I-004

INFLUENCES OF WATER MANAGEMENT AND FERTILITY ON RICE GROWTH AND YIELD,

Oelke, E. A., and Mueller, K. E.
California University, Davis, Dept of Agronomy.
Agronomy Journal, Vol. 61, No. 2, p 227-230, March-April 1969. 1 fig, 4 tab, 12 ref.

Descriptors: *Rice, *Nitrogen, *Water management, Plant populations, Moisture content.
Identifiers: Dry weight accumulation, Leaf area.

Several water management systems for water-seeded rice (Oryza sativa L.), each with several nitrogen levels, were compared for 3 years as to their influence on growth and yield. A shallow (4cm) water depth all season consistently gave higher yields than intermediate (8cm), deep (18cm), or fluctuating (4cm and then 18cm) water depths. Relative fertility and varietal responses were similar for all water management systems. Daytime water temperature, tillers per plant, shoot dry weight, plant population, active leaf area per plant, panicles per plant, panicles per square meter, total nitrogen in the shoots at 30 days, and total nitrogen in the grain were greater in shallow water than in the other water management systems. Seedling emergence and flowering were earlier in shallow water, but lodging was greater and total nitrogen in the straw was lower than in the other systems. The greater number of panicles per square meter was the yield component which contributed most significantly to the higher yields obtained with shallow water.

68-69:02I-005

EFFECT OF IRRIGATION ON RECOVERY OF APPLIED NITROGEN BY COTTON,

Doss, B. D., and Scarsbrook, C. E.
Agricultural Research Service, Thorsby, Alabama.
Agronomy Journal, Vol. 61, No. 1, p 37-40, January-February 1969. 3 fig, 7 tab, 10 ref.

Descriptors: *Irrigation, Nitrogen, Cotton, Fertilizer, Root development.
Identifiers: Dry matter production, Root growth, Soil moisture extraction.

Field studies were conducted on a Greenville fine sandy loam to determine the effects of soil moisture regime and N rate on recovery of applied N by cotton. In general, irrigation decreased the percentage of N in plants but tended to increase total N uptake as a result of the increase in dry matter production. Applied N increased both the N percentage and total N uptake of plants, either with or without irrigation. The slopes of the linear regression equations for nitrogen recovery on nitrogen applied for irrigated cotton were about twice as large as those for unirrigated cotton. Five years' data for both irrigated and unirrigated cotton closely fit the regression equation $\log Y = 2.333 + 0.727 \log_N$ where Y = dry matter yield and X = N uptake.

68-69:02I-006

MOISTURE CONTENT OF COTTON LEAVES AND PETIOLES AS RELATED TO ENVIRONMENTAL MOISTURE STRESS,

Longenecker, D. E., and Lyerly, P. J.
Texas A&M University, El Paso, Dept of Agronomy.
Agronomy Journal, Vol. 61, No. 5, p 687-690, September-October, 1969. 3 fig, 16 ref.

Descriptors: *Cotton, *Moisture content, *Soil moisture, Irrigation, *Moisture stress, Soil-water-plant relationships.
Identifiers: *Petioles.

Moisture content of topmost mature cotton (gossypium) leaves and petioles, from irrigation to permanent wilting, was determined directly in two studies -- one in the greenhouse and one in the field. Fresh weight moisture percentages of both leaves and petioles were shown to decrease gradually as soil moisture was depleted, dropping more rapidly near permanent wilting. Petioles showed consistently higher moisture percentages and more uniform depletion curves than leaves throughout the moisture extraction periods. This suggests that cotton petioles may be more reliable and more useful indicators of the constantly changing plant-soil-moisture relationship than leaves.

68-69:02I-007
RESTORING PRODUCTIVITY ON PULLMAN SILTY CLAY LOAM SUBSOIL UNDER LIMITED MOISTURE,
Eck, H. V.
Agricultural Research Service, Bushland, Texas.
Soil Science Society of America Proceedings, Vol. 33, No. 4, p 578-581, July-August 1969. 5 fig, 1 tab, 10 ref.

Descriptors: *Soil water, *Soil-water-plant relationships, *Nitrogen, Fertilization, Productivity, Water requirements, *Crop response.
Identifiers: *Water use efficiency, Topsoil removal and accumulation.

Applied fertilizer restored grain sorghum (Sorghum vulgare) yields on 10-cm cut Pullman silty clay loam to 93% of those obtained on uncut soil. On 20-, 30-, and 41-cm cuts, yields were restored to 87% of those on uncut soil. Soil water storage, water use, and water-use efficiency data revealed that differences in soil water storage and use were responsible for differences in yield when fertility was not limiting. Topsoil removal decreased and fill increased water-holding capacity of the soil profile. Topsoil removal decreased water loss from fallowed soil, but fill had little effect. N was the only added nutrient required to produce highest yields obtained under limited moisture conditions in this study. Inadequately fertilized treatments used less water than adequately fertilized ones, but water-use efficiency was greater where plant nutrients were adequate.

68-69:02I-008
EFFECT OF MOISTURE REGIMES AND HARVESTS ON EFFICIENCY OF WATER USE BY TEN FORAGE CROPS,
Powell, R. D., and Kardos, L. T.
The Pennsylvania State University, Agricultural Experiment Station.
Soil Science Society of America Proceedings, Vol. 32, No. 6, p 871-874, November-December 1968. 6 tab, 10 ref.

Descriptors: *Legumes, *Crop production, *Irrigation effects, Irrigation efficiency, Evapotranspiration.
Identifiers: *Grasses, *Blaney-Criddle values, *Harvest effects.

The total amounts and rates of depletion of soil water required to produce dry matter by 10 crops were studied. Two experiments with forages were conducted, one being managed to simulate pasture and the other being managed for hay. Three levels of soil moisture management were used in each experiment: control (M_0), irrigation when the available soil water at the 10 cm depth was 85% depleted (M_1), and irrigation when available soil water at the 10 cm depth was 30% depleted (M_2). On the basis of total harvest for all the species, most efficient use of water occurred at the M_0 irrigation level. Also, most efficient use of water occurred prior to the first harvest and least efficient use usually occurred during the period after the first harvest but prior to the second harvest. Ladino clover and ladino-orchardgrass (Trifolium repens-Dactylis glomerata) harvested to simulate pasture were less efficient in using water than the other forages which were managed for hay. Alfalfa swards (Medicago sativa) managed for hay were more efficient than the other swards and the legume-grass combinations differed only slightly from legumes alone. Measured values for rates of moisture depletion per day of all unirrigated forages were generally smaller than values computed by using the Blaney-Criddle formula. The measured values of the irrigated forages approached the Blaney-Criddle values more closely.

68-69:02I-009
SOIL WATER SUPPLY AND DEPLETION PATTERN DIFFERENTIATE AMONG ZEA MAYS L. SINGLE- AND DOUBLE-CROSS HYBRIDS,
Bruce, R. R., Sanford, J. O., Grogan, C. O., and Myhre, D. L.
Agricultural Research Service, Watkinsville, Georgia.
Agronomy Journal, Vol. 61, p 416-421, May-June 1969. 6 fig, 9 tab, 6 ref.

Descriptors: *Irrigation, *Crop response, *Corn, *Irrigation effects, Crop production, *Phenology, Soil water.
Identifiers: *Zea mays L.

The relationship of irrigation response of several double- and single- cross Zea mays L. hybrids to inbred line composition and effectiveness in supplying the plant water requirements from the soil water supply was investigated. An experiment involving 25 double-cross hybrids showed that 15 of these hybrids gave a 10% or greater grain yield response to irrigation, whereas the remainder showed very little or no yield increase. Certain hybrids produced about as well without irrigation as the highest yielding irrigation-responsive hybrids. Subsequent experiments examined the irrigation response of several single-cross hybrids and their double-cross products. In a season of severe drought requiring major irrigation, yield response of the double-cross products to irrigation was predicted very well by averaging the yield response of the four non-parental single crosses of the four inbreds involved.

68-69:02I-010
NITROGEN ECONOMY OF CROPPED AND UNCROPPED FLOODED RICE SOILS UNDER FIELD CONDITIONS,
Racho, V. V., and De Datta, S. K.
The International Rice Research Institute, Los Banos, Laguna, Philippines.
Soil Science, Vol. 105, No. 6, p 419-427, June 1968. 6 fig, 2 tab, 23 ref.

Descriptors: *Nitrogen, Fertilization, *Flood irrigation, Crop production, Rice, Nitrogen cycle.

Most of the mineral nitrogen present in a flooded Maahas clay was ammonium nitrogen. Although the amount at transplanting was closely related to the amount of nitrogen fertilizer added, the amount in all treatments at harvest was similar, suggesting that there was no carry-over of fertilizer nitrogen, irrespective of rates of application, for a succeeding rice crop. Substantial amounts of mineral nitrogen remaining in the soil at harvest represent a reserve for use by a subsequent crop provided the soil is kept submerged in the interim. The data indicate that if adequate fertilizer nitrogen is incorporated before transplanting, it should not be necessary on this soil to apply further nitrogen at the panicle primordium initiation stage of an early maturing, lodging-resistant rice variety. Considerable quantities of nitrogen were unaccounted for at harvest and the amount increased with fertilizer application These discrepancies remain unexplained and indicate the need for further research. Plant nitrogen analyses suggested that rate of nitrogen fertilizer application did not affect the removal of soil nitrogen by the rice crop. Estimated fertilizer recovery by the plant decreased with increased fertilizer application.

68-69:02I-011
FUNCTIONS FOR COTTON (GOSSYPIUM HIRSUTUM L.) PRODUCTION FROM IRRIGATION AND NITROGEN FERTILIZATION VARIABLES: II. YIELD COMPONENTS AND QUALITY CHARACTERISTICS,
Grimes, Donald W., Dickens, W. L., and Anderson, W. D.
California University, Davis, Dept of Water Science and Engineering.
Agronomy Journal, Vol. 61, No. 5, p 773-776, September-October 1969. 3 fig. 3 tab, 16 ref.

Descriptors: *Crop response, *Cotton, *Irrigation efficiency, *Plant growth, *Nitrogen, Arid lands, California, Soil-water-plant relationships, Statistics, Crop production, Fibers (Plant).
Identifiers: *Production function, Plant quality.

Tests were conducted on 2 soils in the arid San Joaquin Valley of California to develop relationships of applied irrigation water and nitrogen to cotton yield components, plant height and fiber quality. Equations were developed relating plant height, flowers, bolls and lint quality to the amount of water applied for 3 levels of nitrogen. There was a positive correlation between yield and number of flowers and bolls. Plant height continued to increase with additional water, but beyond a certain point lint yield responded negatively. Fiber quality was primarily a function of water rather than nitrogen.

68-69:02I-012
FUNCTIONS FOR COTTON (GOSSYPIUM HIRSUTUM L.) PRODUCTION FROM IRRIGATION AND NITROGEN FERTILIZATION VARIABLES: I.YIELD AND EVAPOTRANSPIRATION,
Grimes, D. W., Yamada, H., and Dickens, W. L.
California University, Davis, Dept of Water Science and Engineering.
Agronomy Journal, Vol. 61, p 769-773, September-October 1969. 6 fig, 2 tab, 13 ref.

Descriptors: *Crop production, *Crop response, *Fertilization, *Irrigation, *Cotton, Nitrogen, Evapotranspiration, Soil moisture.
Identifiers: *Production function, Second-degree polynomial, Water-use efficiency.

Cotton lint yield, evapotranspiration (ET), and efficiency of water use were characterized with 2nd-degree polynomials as functions of the quantity of irrigation water and nitrogen applied on two widely different soils. Excessive vegetative plant develepment at high input levels of irrigation water and nitrogen resulted in production functions for lint yield having negative interaction coefficients. By placing lint yield on a relative basis for the two soils, it was possible to express relative yields as a function of ET with a single quadratic regression equation ($R. Y. = 266.4 + 10.72 (ET) - 0.079(ET)^2$; $R^2 = 0.78$). Total seasonal ET increased at a decreasing rate with increased water application up to an addition of 119 cm of water during the entire growing season. Peak daily rates of soil moisture depletion were 1.07 cm, occurring near the time when maximum leaf area was attained. Water use efficiency (kg lint per cm of water used) was improved in some cases with the addition of nitrogen.

68-69:02I-013
EFFECTS OF EXTERNAL SALT CONCENTRATIONS ON WATER RELATIONS IN PLANTS: VI. EFFECTS OF THE EXTERNAL OSMOTIC WATER POTENTIAL ON SOLUTE REQUIREMENT, SALT TRANSPORT, KINETICS AND GROWTH RATES OF LEAVES,
Oertli, J. J.
California University, Riverside, Dept of Soils and Plant Nutrition.
Soil Science, Vol. 105, No. 5, p 302-310, 1968. 12 fig, 9 ref.

Descriptors: *Salts, *Soil-water-plant relationships, *Osmotic pressure, *Plant growth, *Arid lands, Salinity, Plant physiology, Air environment, Soil environment, Environmental effects, Vegetation effects, Leaves, Moisture stress, Turgidity, Solutes, Soil water, Cytological studies, Barley, Kinetics, Xylem, Growth rates, Isotherms.
Identifiers: *Water potential, *Salt transport (Plants).

This is one of a series of reports on effects of salt in soil water on plant-water relations. The experiment measured osmotic potential in the petiole and external solution using a Mechrolab vapor pressure osmometer. Turgor pressure of expanding leaf cells was arbitrarily set at 5 bars. The external solute requirement required to maintain this turgor pressure as water potential varied was measured. The results are presented in graphic form. Different turgor pressures would result in parallel shifts in the curve. Results indicate that solute requirements to maintain turgor pressure in leaves increase in proportion to external water stress. Salt transport through the plant decreases in efficiency with increasing salt accumulations. In elongating cells solute requirements must be met continuously. It follows then that cell expansion and leaf growth should be less at either low or high salt concentrations. The optimum level will be somewhere in the middle. Experimental results with barley seedlings supported this conclusion. It was observed that high atmospheric moisture stress, common in arid lands, decreased growth rates by increasing solute requirements. Growth reduction, even without visible leaf injury caused by salinity, is a result of osmotic relationships.

68-69:02I-014
EFFECTS OF EXTERNAL SALT CONCENTRATIONS ON WATER RELATIONS IN PLANTS: IV. THE COMPENSATION OF OSMOTIC AND HYDROSTATIC WATER POTENTIAL DIFFERENCES BETWEEN ROOT XYLEM AND EXTERNAL MEDIUM,
Oertli, J. J., and Richardson, W. F.
California University, Riverside, Dept of Soils and Plant Nutrition
Soil Science, Vol. 105, No. 3, p 177-183, 1968. 7 fig, 10 ref.

Descriptors: *Salinity, *Osmotic pressure, *Hydrostatic pressure, Circulation (Plants), Plant physiology, Transpiration, Moisture uptake, Microenvironment, Soil-water-plant relationships, Irrigation effects, Root zone, xylem.

Experiments on sunflower plants and tomato plants show that variations of the osmotic potential difference between root xylem and external medium are nearly compensated for by variations of the hydrostatic potential difference, so that their sum stays nearly independent of external-solution concentrations having osmotic potentials of 0 to -5 bars. Increasing salt concentrations only altered this relationship slightly while reducing transpiration rates substantially. This absence of proportionality between transpiration rate change and change in the net osmotic-hydrostatic potential differences is probably the result of a solute accumulation at the root surface and in the root free space. Other explanations include change of root permeability for water, due to the salinity, or systematic error in experimental procedures.

68-69:02I-015
EFFECTS OF EXTERNAL SALT CONCENTRATIONS ON WATER RELATIONS IN PLANTS: V. SIGNIFICANCE OF EXTERNAL WATER-POTENTIAL AND SALT-TRANSPORT KINETICS ON RATE OF CELL EXPANSION,
Oertli, J. J.
California University, Riverside, Dept of Soils and Plant Nutrition.
Soil Science, Vol. 105, No. 4, p 216-222, 1968. 2 fig, 18 ref.

Descriptors: *Salinity, *Saline soils, *Soil-water-plant relationships, *Plant physiology, *Plant growth, *Osmotic pressure, Turgidity, Xylem, Kinetics, Cytological studies.
Identifiers: *Turgor pressure, Salt transport.

Soil salinity generally results in a reduction of plant growth. This report theoretically investigates the effect of external salt concentration and of the solute transport on cell elongation. When internal hydrostatic pressure exceeds external pressures, plant cells elongate. If water transport into the cell occurs in response to salt addition to the vacuole, the rate-limiting factor is probably the salt, and not the water transport. Solute requirement is a function of total water potential at the root surface. Salt transport rates depend upon external concentration and obey kinetics of decreasing efficiency. The cell elongation rate depends upon external concentration; the time for unit elongation decreases, passes through a minimum and subsequently increases in the range of saline conditions. Experimental support of the conclusions will be presented in a subsequent paper.

68-69:02I-016
ALFALFA WATER TABLE INVESTIGATIONS,
Tovey, Rhys.
Agricultural Research Service, Reno, Nevada.
American Society of Civil Engineers Proceedings, Journal of the Irrigation and Drainage Division, Vol. 95, No. IR4, Paper 6974, p 525-535, December 1969. 7 fig, 1 tab, 7 ref.

Descriptors: *Evapotranspiration, *Consumptive use, *Alfalfa, *Groundwater movement, *Water level fluctuations, Water table, Irrigation, Irrigation water, Irrigation efficiency, Water demand, Water utilization, Lysimeters, Soil moisture.
Identifiers: Water use (Alfalfa).

Use of water by alfalfa growing under high water table conditions was studied to determine the irrigation requirement. A three-season average of consumptive use and yield of alfalfa, disregarding soil textures, showed an almost straight-line relationship with water table depth for the nonirrigated treatment. The nonirrigated alfalfa showed the effects of static water table depth on the consumptive use and yield of alfalfa. Peak consumptive use occurred when the alfalfa was at or approaching the one-tenth bloom stage and temperatures were high. Only minor differences in the growth of alfalfa were found for the various static water table, soil, and irrigation treatments. The alfalfa plants in the lysimeters showed good root development, with roots in the saturated zone and enlarged white rootlets extending below the water table level. Pan evaporation, net radiation, and the Olivier method adequately predicted cumulative consumptive use for an 8-ft water table, but were low for 2-ft and 4-ft water table depths. None of the prediction methods reflected peak consumptive use periods for alfalfa grown in the presence of static shallow water tables.

68-69:02I-017
CROP RESPONSES TO RAINFALL MULTIPLIERS,
Wittmuss, H. D., and Ehlers, P. L.
Nebraska University, Lincoln, Agricultural Experiment Station.
American Society of Agricultural Engineers Transactions, Vol. 11, No. 4, p 484-486, July-August 1968. 1 fig, 4 tab, 7 ref.

Descriptors: *Water harvesting, *Water utilization, *Crop response, *Irrigation efficiency, *Semiarid climates, Great Plains (Nebr), Sorghum, Wheatgrass, Crop production, Soil-water-plant relationships, Rainfall, Bench leveling, Slopes, Water yield improvement.
Identifiers: *Rainfall multipliers, *Sealed contributing areas.

In a study of water-use efficiency in a semiarid area of Nebraska, rainfall multipliers were installed. They consisted of sealed contributing areas on a 3% slope above level bench areas. The increased available water was used on grain sorghum and intermediate wheatgrass plots. With 100, 150, 200, and 250 percent of rainfall availability, the sorghum plots yielded 3.9, 3.6, 3.2, and 2.8 bu per acre-inch of water, respectively (1963). The grain yield was highest on the 195 percent plot. With 100, 150, 200, and 250 percent of rainfall availability, the wheatgrass plots yielded 130, 140, 171, and 148 lb of hay per acre-inch of water, respectively (1964-1966). In 1966 irrigated plots of wheatgrass produced 50 percent more hay than any rainfall multiplier plot during the three-year period. However, the plots receiving 200 percent rainfall in 1965 produced as much hay per unit of water as the irrigated plots. Further studies are needed to improve water harvesting and efficient water utilization in semiarid areas such as the Great Plains.

68-69:02I-018
MONITORING COTTON PLANT STEM RADIUS AS AN INDICATION OF WATER STRESS,
Namken, L. N., Bartholic, J. F., and Runkles, J. R.
Agricultural Research Service, Weslaco, Texas.
Agronomy Journal, Vol. 61, p 891-893, November-December 1969. 3 fig, 4 ref.

Descriptors: *Cotton, *Soil-water-plant relations.
Identifiers: Water stress, Transducer, Growth characteristics, Leaf water potential.

Cotton plant water stress was monitored continuously during a drying cycle by measuring microchanges in plant stem radius with a linear variable displacement transducer (LVDT). Plant stem contraction was directly related to the degree of leaf water stress, and plant stem radius was very responsive to changes in the energy load at the evaporating surface. The LVDT provided a stable, trouble-free method for monitoring relative plant water stress under field conditions without destroying plant tissue.

68-69:02I-019
EFFECTS OF VERTICALLY HETEROGENEOUS SOIL SALINITY ON PLANT GROWTH AND WATER UPTAKE,
Shalhevet, J., and Bernstein, L.
California University, Riverside.
Soil Science, Vol. 106, No. 2, p 85-93, August 1968. 5 fig, 2 tab.

Descriptors: *Saline soils, *Alfalfa, *Root systems, Equations, Growth chambers, *Crop response, Osmosis, Salt tolerance, Irrigation effects, *Moisture uptake, Absorption, On-site data collections, Soil-water-plant relationships, Root zone, Water utilization.

By means of a root-compartment technique, the effect of non-uniform distribution of salts in the soil on alfalfa growth and water uptake was studied at Riverside, California. The root system was divided by a horizontal wax membrane into two equal depth sections. Each chamber was salinized and irrigated separately through a wick distribution system. It was found that mean salinity of the root zone was a good estimate of effective salinity and that the salinity of both chambers was equally significant in causing yield reductions. Water uptake from each chamber was strongly influenced by salinity of both chambers. It decreased as salinity of the chamber increased and increased at about half the rate as salinity of the complementary chamber increased. Total plant water potentials were also computed from water-uptake rates and soil-water potentials, using linear-flow equations.

68-69:02I-020
AERODYNAMIC AND SURFACE FACTORS IN EVAPORATION,
Szeicz, G., and Endrodi, Gabriella. and Tajchman, S.
Rothamsted Experimental Station, Harpenden, Hertfordshire (England).
Water Resources Research, Vol. 5, No. 2, p 380-394, April 1969. 6 fig, 3 tab, 44 ref.

Descriptors: *Evapotranspiration, *Evaporation, *Crops, Energy budget, Diffusion, Advection, Stomata, Winds, Turbulence, Solar radiation.
Identifiers: Eddy conductivity, Roughness (Aerodynamic).

Measurements were made of the roughness length and other aerodynamic qualities of pine forest, lucerne, and potatoes in Germany, and analyzed with additional data obtained from publications. For pliable crops, roughness length decreases by 1/2 for winds of 1-3 m/sec; in this range of winds, roughness length is approximately equal to 1/10 the crop height. Eddy conductivities are about 3 times open-water values for crops and 30 times open-water values for trees. Stomatal diffusion resistance values in trees are always 2-4 times as great as in crops, with winds from 1.0-1.5 cm/sec. Energy balance computations give estimates of evaporation for open water, pine forest, potatoes, and lucerne that agree within 5-15% with measurements in England and California.

68-69:02I-021
INFLUENCE OF TEMPERATURE AND LEACHATE ON GERMINATION OF ATRIPLEX POLYCARPA,
Cornelius, D. R., and Hylton, L. O.
Agricultural Research Service, Berkeley, California.
Agronomy Journal, Vol. 61, No. 2, p 209-211, March-April 1969. 3 fig, 2 tab, 3 ref.

Descriptors: Browse utilization, Range management, Ranges, *Inhibitors, Plant growth substances, *Germination, Plant growth, *Vegetation establishment, Soil moisture, *Soil temperature.
Identifiers: *Desert saltbush, *Atriplex polycarpa, *Browse plant.

Desert saltbush, Atriplex polycarpa, a valuable native browse plant, occurs on dry rangeland in central and southern California. Germination was determined at temperatures from 5 to 35C at 5° intervals. Highest germination occurred at 20C on the 5th day in germinators and at 15C after 14 and 30 days. Germination declined uniformly from the 15 or 20C level to lowest and highest temperatures. For treatment A one set of seed and blotters was moistened with tap water for duration of 30 days. In treatment B the seed was soaked (leached) for 48 hours; then tap water was used to keep blotters and seed moist. In treatment C seeds were kept moist by using the leachate from the seed that had been soaked. Highest germination occurred after treatment B; lowest after treatment C; and treatment A was between C and B in effectiveness. The presence of some undetermined substances in the leachate severely inhibited germination in treatment C. Partial removal of the leachate from the seed enhanced germination in treatment B.

68-69:02I-022
PLANT MOISTURE STRESS: A PORTABLE FREEZING-POINT METER COMPARED WITH THE PSYCHROMETER,
Cary, J. W., and Fisher, H. D.
Snake River Conservation Research Center, Kimberly, Idaho.
Agronomy Journal, Vol. 61, No. 2, p 302-305, March-April 1969. 5 fig, 2 tab, 11 ref.

Descriptors: *Diffusion, *Moisture stress, *Hygrometry, Soil-water-plant relationships.
Identifiers: *Plant-water relations, *Freezing-point depression.

A small portable instrument for measuring the freezing-point depression of plant tissue has been developed for field use. The instrument is easy to operate and can be constructed from materials costing less than $100. Moisture stress measurements made with the freezing-point meter on a variety of plants were compared with vapor pressure psychrometer measurements. Variation between duplicates in the freezing point averaged 1.2 bars, but differences between stress measurements made with the psychrometer and freezing-point instrument averaged 2.6 bars.

68-69:02I-023
SURVIVAL OF PLANTS UNDER PROLONGED FLOODED CONDITIONS,
Yu, P. T., Stolzy, L. H., and Letey, J.
California University, Riverside, Dept of Soils and Plant Nutrition.
Agronomy Journal, Vol. 61, No. 6, p 844-846, November-December 1969. 2 tab, 2 ref.

Descriptors: *Aeration, Corn, Tomatoes, Barley, *Flooding, Root systems, Soil-plant-water relationships.
Identifiers: *Root porosity, *Internal aeration, Flooded treatments.

Barley (Hordeum vulgare L.), corn (Zea mays L.), sunflower (Helianthus annus L.), tomato (Lycopersicum esculentum L.), and "Pato" and "Inia" varieties of wheat (Triticum vulgare L.) were grown in Krilium-stablized Yolo loam in pot culture under greenhouse conditions until the root systems were well established. The plants were then subjected to full-flooded, half-flooded, and temporarily-flooded treatments. Observations of plant growth rates under treatments were made by periodically measuring top and root length. Plants were harvested after 2 to 4 weeks of treatment and the air-filled root porosity was measured for each root system. Reduction in growth rates and dry weights for all plants was observed in full-flooded as compared to non-flooded conditions. These results suggest that tolerance to excess moisture was related to plant internal aeration which might be achieved by increases in root porosity. Reduction in weight and growth rates was significant in full-flooded but not significant in half-flooded conditions when compared to control.

68-69:02I-024
EFFECTS OF TILLAGE, NO TILLAGE, AND MULCH ON SOIL WATER AND PLANT GROWTH,
Jones, J. N., Jr., Moody, M. E., Lillard, J. H.
Agricultural Research Service, Blacksburg, Virginia
Agronomy Journal, Vol. 61, No. 5, p 719-721, September - October, 1969. 2 fig, 3 tab
7 ref.
(See 68-69:03F-027)

SECTION VII

WATER CYCLE - EROSION AND SEDIMENTATION (Group 02J)

68-69:02J-001
INTERDEPENDENCE OF WATER DROP ENERGY AND CLOD SIZE ON INFILTRATION AND CLOD STABILITY,
Moldenhauer, W. C., and Kemper, W. D.
Iowa State University, Ames, Dept of Agronomy.
Soil Science Society of America Proceedings, Vol. 33, No. 1, p 297-301, January - February 1969. 8 fig, 3 tab, 17 ref.

Descriptors: *Infiltration, *Impact (Rainfall), *Soil structure, *Soil surface, *Runnoff, Soil erosion.
Identifiers: Soil surface sealing.

The decline of intake rates as successive increments of water drop energy were applied to various sizes of soil fragments of two Iowa and two Colorado soil types is presented. There was a wide spread between intake rate of the 8- to 20-mm size range and those of all other sizes after the first increment (1.25 cm as 5-mm drops) was applied. The intake rate of the 8- to 2-mm size declined rapidly after the first or second increment. Final intake rates were not correlated with aggregate stability in this study. There was a negative correlation between clay content and final intake rates. Final intake rates after disintegration of large soil fragments in many cases were lower than when initial size ranges were small.

68-69:02J-002
ADSORPTION OF PHOSPHORUS BY LAKE SEDIMENT,
Harter, R. D.
Connecticut Agricultural Experiment Station, New Haven.
Soil Science Society of America Proceedings, Vol. 32, No. 4, p 514-518, July-August 1968. 5 fig, 1 tab, 12 ref.

Descriptors: *Sediments, *Phosphorus, Eutrophication, Algae.
Identifiers: *NaOH and NH_4F extractable phosphorus

The sediment of a eutrophic lake is capable of adsorbing a large amount of phosphorus from the water. To study the sorption mechanism, between 0 and 2.2 mg P was added to 0.1-g sediment samples (1:50 sediment-solution ratio). After equilibrium had been established, P remaining in solution was determined, and adsorbed P was extracted with 0.5N NH_4F and 0.1N NaOH. Whereas all P adsorbed into the NaOH-extractable fraction appeared to occur as an iron phosphate, NH_4F apparently extracted P bonded by two different mechanisms. When less than about 0.1 mg P was added, NH_4F extracted a tightly bonded form of P, probably occurring as an aluminum phosphate. When more than 0.1 mg P was added, additional P in a more loosely bonded form was adsorbed into the NH_4F-extractable fraction. The loosely bonded P appeared to be independent of Al content of the sediment, and could be removed by successive water extraction. The capability of the sediment to adsorb considerably loosely bonded P means that large influxes of P into the lake may be held temporarily and subsequently released to growing plants and algae.

68-69:02J-003
A SYSTEM FOR MEASURING AND SAMPLING RUNOFF CONTAINING SEDIMENT AND AGRICULTURAL CHEMICALS FROM NEARLY LEVEL LANDS,
Willis, G. H., Laflen, J. M., and Carter, C. E.
Agricultural Research Service, Baton Rouge, Louisiana.
American Society of Agricultural Engineers, Transactions, Vol. 12, No. 5, p 584-587, September-October 1969. 1 fig, 4 tab, 7 ref.

Descriptors: *Sediments, Chemicals, Water resources, Agriculture, Head loss, *Runoff, Samplers, Rainfall, Watersheds (Basins), Parshall flumes, Weirs, Volume, Analysis, Endrin, Chromatography, Clays, Water pollution, Silts, Pollutants, Models, *Agricultural chemicals, Measurement, *Water pollution sources, Pesticides, Nitrates, Water analysis.
Identifiers: Coshocton sampler.

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Controversies over suggestions that agricultural chemicals might be polluting water resources of this nation make it imperative that the quality of runoff from agricultural lands be characterized accurately. To do this, special care must be exercised to collect samples that truly represent the runoff. A Parshall flume, Geib multislot divisor, sump pump, and storage tanks, appropriately arranged, provided a system that measured runoff with reasonable accuracy and collected representative samples of the runoff. Very little head loss through the system was experienced. The vertical distance from the flume entrance to the divisor outlet was only 4.5 in. There were little differences in silt, clay, NO_3-N, or endrin contents in overall comparisons between slot and channel samples for all flow rates and sediment concentrations tested. All endrin entering the system was recovered, proportionately, in the sample.

68-69:02J-004
SOIL EROSION CONTROL PRACTICES IN PERSPECTIVE,
Jacobson, P.
Harza Engineering Company, Chicago, Illinois.
Journal of Soil and Water Conservation, Vol. 24, No. 4, p 123-126, August 1969.
2 fig, 10 ref.

Descriptors: *Soil erosion, *Erosion control, *Check structures, *Farm management, Contour farming, Embankments, Land forming, Land management, Slope protection, Soil conservation, Strip cropping, Terracing, Water control.
Identifiers: *Tillage practices.

Many standard soil erosion control practices have proven impossible to sell to farmers, and some are no longer applicable to farming practices now in use. The standard practices are reviewed and suggestions are made for their modification or replacement in cases of lack of use or obsolescence. Contouring is not suitable for large-scale mechanized farming in humid areas. Crop rotation is no longer necessary to add nitrogen, and is not used by farmers who do not need grass crops. Strip cropping is seldom used in corn areas or by non-users of grass. Terracing is effective if constructed properly but more research on the relation of terrace shape to land and climate conditions is needed to utilize the system well. Tillage practices are used well in many cases, but more need to be established for various crop-weather-runoff situations. It is concluded that Corn Belt farmers will accept only no-flow till-plant minimum tillage programs with water control by storage fills across waterways. Use of this system can reduce downstream sediment and nutrient loads to very low levels.

68-69:02J-005
USE OF RADIOACTIVE ^{59}Fe FOR TRACING SOIL PARTICLE MOVEMENT PART I. FIELD STUDIES OF SPLASH EROSION,
Coutts, J. R. H., Randil, M. F., Nowland, J. L., and Tinsley, J.
University of Aberdeen, Dept of Soil Science.
Journal of Soil Science, Vol. 19, No. 2, 1968. 6 fig, 3 tab, 3 plates, 5 ref.

Descriptors: *Rainfall, *Impact rainfall, *Soil erosion, Soil mechanics, Wind erosion, Slopes, Raindrops, *Radioactivity techniques.

^{59}Fe appeared to be a suitable tracer for investigating soil particle movements and experimental results have demonstrated quantitatively that, when a dilute radioactive $FeCl_3$ solution is applied to soils of varied texture, this isotope is firmly absorbed and shows little tendency to downward movement by leaching. Addition of the chelating compound di-ethylene triamine penta-acetic acid (DTPA) greatly improves the uniformity of absorption. The surface movement of labelled soil particles was readily detected by direct scintillation counting of grid reference points over trays of soil exposed in the field or of core samples transported to the laboratory, and less sensitivity by autoradiographs on X-ray film applied to the surface of ground plots. Under the summer and winter weather conditions prevailing at Aberdeen, the displacement of soil from bare surfaces by rain splash is markedly affected by wind speed and direction. Even with light showers, relatively low wind speeds and slopes not exceeding 6^0, some of the labelled soil particles migrated distances of 60 cm from the treated areas in the centre of ground plots 2 m square.

68-69:02J-006
USE OF RADIOACTIVE ^{59}Fe FOR TRACING SOIL PARTICLE MOVEMENT PART II. LABORATORY STUDIES OF LABELLING AND SPLASH DISPLACEMENT,
Coutts, J. R. H., Kandil, M. F., and Tinsley, J.
University of Aberdeen, Dept of Soil Science.
Journal of Soil Science, Vol. 19, No. 2, 1968. 6 fig, 9 tab, 9 ref.

Descriptors: *Rainfall, *Impact rainfall, *Soil erosion, Soil mechanics, Wind erosion, Slopes, Raindrops, *Radioactivity techniques.

The field studies reported in Part I were complemented by laboratory investigations on the labelling of soils and the movement of soil particles by simulated rainfall splash. Of various labelling techniques tested, the most uniform absorption of ^{59}Fe, as shown by autoradiographs, was secured by adding DTPA chelating reagent to the $FeCl_3$ solution used for wetting soil peds under vacuum. Studies on the specific radioactivity of the Atterberg textural fractions, separated from clay loam, sandy loam, loam and peat soils before and after labelling, showed in all cases that the clay fraction was dominant in retention of ^{59}Fe. The radioactivity was so firmly absorbed that its movement could be used to trace both the horizontal and vertical displacements of labelled soil particles by scintillation counting of autoradiographic techniques. Tests with a rainfall simulator showed a close correlation between the weights and radioactivities of splashed soil particles. Gravimetric data obtained from unlabelled clay loam and sandy loam soils subjected to 'rainfall' of differing intensity, drop size and height of fall gave a linear relationship on a logarithmic scale between mass of particles and distance of splash. Calculation of the kinetic energy lost by water drops on impact with the soil and that imparted to the splashed soil particles show that the relationship depends principally on the rainfall intensity and the texture of the soil.

68-69:02J-007
SOIL MOVEMENT ON IRREGULAR SLOPES,
Young, Robert A., and Mutchler, Calvin K.
Agricultural Research Service, Morris, Minnesota.
Water Resources Research, Vol. 5, No. 5, p 1084-1089, October 1969. 2 fig, 4 tab, 11 ref.

Descriptors: *Soil erosion, *Model studies, *Simulated rainfall, Gully erosion, Rill erosion, Sheet erosion, Runoff, Slopes, Topography, Soil conservation, Rainfall intensity, Tracers, Dye releases.
Identifiers: Soil erosion test plots, Soil movement tracers.

Soil loss and runoff were measured from concave, uniform, and convex slopes subjected to simulated rainfall. Fluorescent glass particles and microrelief measurements were used to determine soil movement patterns in the slopes. For slopes of equal average steepness, a concave shape greatly reduced the total sediment loss in comparison with that from either a uniform or convex slope. Average slope steepness was not a good indicator of soil delivery past a given point except for a uniform slope. In general, soil losses from irregular slopes depend on the steepness of a short section of that slope immediately above the point of measurement. Soil movement off the plots was primarily transported by raindrop splash to a rill system and then transported down the slope by runoff in the rill system. A breakdown of the rill system occurred on the bottom of the concave slopes because of decreasing local steepness, resulting in sheet flow and sediment deposition.

68-69:02J-008
GRADED FURROWS FOR WATER EROSION CONTROL,
Richardson, C. W., Baird, R. W., and Fryrear, D. W.
Blacklands Experiment Watershed, Riesel, Texas.
Journal of Soil and Water Conservation, Vol. 24, No. 2, p 60-63, March-April 1969. 5 fig, 2 tab, 4 ref.

Descriptors: *Furrow systems, *Erosion control, *Grading, *Runoff, *Slopes, Terracing, Irrigation efficiency, Texas, Crop production, Demonstration watersheds, Cultivated lands, Peak discharge.

At the Blackland Research Center, Temple, Texas, and the Blacklands Experimental Watershed, Riesel, Texas, research is underway to evaluate the effectiveness of a system of graded furrows as an erosion control measure. A system of furrows with a

1 percent grade successfully controlled erosion on areas with slopes up to 3 percent. Operating farm equipment on the furrow ridges was not appreciably more difficult than on flat-tilled areas, and crop yields were comparable to yields obtained on nearby conventionally tilled areas. Runoff and soil loss data from graded furrows up to 930 feet long indicated that both unit runoff and soil loss increased as furrow length increased. Graded furrows appeared to be a method of increasing the efficiency of field operations while protecting the soil from erosion.

68-69:02J-009
USE OF TRACER TECHNIQUE IN SOIL EROSION RESEARCH,
McHenry, J. Roger.
Agricultural Research Service, Oxford, Mississippi.
American Society of Agricultural Engineers Transactions, Vol. 11, No. 5, p 619-625, September-October 1968. 2 fig, 2 tab, 31 ref.

Descriptors: *Tracers, *Radioisotopes, *Soil erosion, Tagging, Alpha rays, Tritium, Beta rays, Gamma rays, Bibliographies, Sampling, Half life, Radioactivity, Research equipment, Radiation measurement, Soil science, *Erosion.
Identifiers: Scintillation counters.

A review is given for those considering the use of radioactive tracers in soil erosion research. The selection and characteristics of a tracer, including half life, specific activity, type of emission, and chemical and physical form are discussed. The method for calculating the required amount of the tracer is described; the general theory of using tagged particles as tracers and of isotopic dilution is given. Selecting and preparing a radioisotope, and tagging and seeding particles in the experimental area, are described. Methods are outlined for detection, sample counting, and data reduction. Advantages and disadvantages are presented for using radioisotopes as tracers. In erosion research, the measurement of volume movement of a soil mass is difficult to evaluate. If the entire soil mass can be traced or if the tracer can be mixed uniformly in the system samples, quantitative results can be calculated. These conditions do not usually occur and the result is that tracer data are more qualitative than quantitative.

68-69:02J-010
EFFECT OF EROSION-CONTROL LAND TREATMENT ON FLOW FROM AGRICULTURAL WATERSHEDS,
Harrold, Lloyd L., and Dragoun, Frank J.
Agricultural Research Service, Washington, D.C.
American Society of Agricultural Engineers Transactions, Vol. 12, No. 6, p 857-861, November-December 1969. 8 tab, 16 ref.

Descriptors: *Flow, *Water yield, *Land treatment, *Agricultural watersheds, *Erosion-control, Storm runoff, Terraces.
Identifiers: *Coshocton, Ohio; *Hastings, Nebraska; *Riesel, Texas; *Treynor, Iowa; Deep loess.

Farming methods that increased the area of grass and trees effectively reduced soil erosion and caused a reduction in annual surface water yield by about 30 percent in Ohio, Nebraska, and Texas. Although level bench terraces in deep loess of western Iowa has little effect on total annual water yield, its stream flow came mostly from aquifers and was distributed fairly uniformly throughout the year. On unterraced watersheds, much of the flow occurred as flashy storm surface runoff. These level terraces caused noticeable reduction in flood peak discharge rates. Major flood peaks in Ohio, Nebraska, and Texas were not affected by erosion-control land treatment. Watershed modeling techniques are not yet advanced to the point of predicting downstream effects on streamflow resulting from headwaters land use changes.

68-69:02J-011
EFFECTS OF UNIT WEIGHT AND SLOPE ON EROSION.
Foster, Richard L,, and Martin, Glen L.
Cornell,Howland, Hayes and Merryfield, Seattle, Washington.
American Society of Civil Engineers Proceedings, Journal of Irrigation & Drainage Division, Vol. 95, No. IR4, Paper No. 6984, p 551-561, December 1969. 9 fig, 2 tab, 6 ref, append.

Descriptors: *Erosion, *Soil erosion, *Slopes, *Soil compaction, Drainage, Rainfall, Roads, Rainfall-runoff relationships, Model studies, Laboratory tests, Statistical methods.
Identifiers: Slope-erosion relations.

Laboratory tests were performed on a fine grained soil to determine the effect of unit weight and slope on erosion and runoff. The tests were conducted on slopes of 1:1, 2:1, and 3:1 using unit weights of 80, 85, 90 and 95 lb per cu ft and a simulated rainfall intensity of 6 in. per hr. After collecting the runoff water and solid particles, the weight of solids eroded and the volume of runoff water were determined. The results and analyses of this study indicate that the slope and unit weight have definite effects on the erosion of unprotected slopes. These indications are: (1) On the flattest slope, the specimens compacted to the lowest unit weight experience the highest rate of erosion; (2) on the steepest slope, the specimens compacted to the highest unit weight experience the highest rate of erosion; and (3) for a given unit weight, there is a unique slope from which the maximum amount of erosion will occur.

68-69:02J-012
RELATION OF SOIL PROPERTIES TO ITS ERODIBILITY,
Wischmeier, W. H., and Mannering, J. V.
Agricultural Research Service, Lafayette, Indiana.
Soil Science Society of America Proceedings, Vol. 33, No. 1, p 131-137, January-February 1969. 1 fig, 4 tab, 17 ref.

Descriptors: *Soil erosion, *Runoff, *Soil physical properties, Soil conservation, Erosion control, Soil stability, Soil strength, Bulk density, Particle size, Soil structure, Soil aggregates, Permeability, Porosity, Soil texture, Saturation, Sands, Silts, Clays, Organic matter, Hydrogen ion concentration, Crops, Grasses, Slopes.
Identifiers: Soil-loss prediction, Soil erodibility, Soil detachment.

A soil's inherent erodibility, which is a major factor in erosion prediction and land-use planning, is a complex property dependent both on its infiltration capacity and on its capacity to resist detachment and transport by rainfall and runoff. The relations of these capacities to soil physical and chemical properties were investigated in a 5-year field, laboratory, and statistical study including 55 selected Corn Belt soils. Properties that contributed significantly to soil-loss variance included percentages of sand, silt, clay, and organic matter; pH, structure and bulk density of plow layer and subsoil; steepness and concavity or convexity of slope; pore space filled by air; residual effects of sod crops; aggregation; parent material; and various interactions of these variables. An empirical equation was derived for calculating the universal soil-loss equation's erodibility factor K for specific soils. Tests of the equation against soils of the older erosion-research stations, for which the erodibility factor is known, substantiated its general applicability over a broad range of medium-textured soils.

68-69:02J-013
INTERRELATIONSHIP BETWEEN PHYSIOGRAPHY, HYDROLOGY, SEDIMENTATION, AND SALINIZATION OF THE LODDON RIVER PLAINS, AUSTRALIA,
Macumber, P. G.
Geological Survey of Australia, Melbourne.
Journal of Hydrology, Vol. 7(1969), No. 1, p 39-57, November 1968. 5 fig, 1 plate, 2 tab, 18 ref.

Descriptors: *Saline soils, *Saturated soils, *Land reclamation, *Drainage, *Irrigation practices, Flood control, Leaching, Alluvium, Water table.
Identifiers: Australia, Loddon River, Aeolian soils.

The causes of salinization of the Loddon River plain, Australia, were studied to attempt to find a means of halting the deterioration of irrigated farms and grazing land. The pattern of salinization was found to be closely linked to the fluvial and aeolian patterns of Quaternary sedimentation, with the most severe salinization in clays and fine soils. Flood control projects eliminated the winter sheet flood which leached salt from the upper soil profile each year, while summer irrigation causes rising water tables and soil salinization. Alluvial sand aquifers are found along some of the streams; pumping them heavily as groundwater drains can be done locally to lower the water table and alleviate soil salinity. Buried alluvial aquifers parallel to surface drainage were found and may also be pumped for drainage.

68-69:02J-014
SOIL EROSION AND CONSERVATION IN NORTHERN JORDAN,
Beaumont, P., and Atkinson, K.
Durham University (England), Dept of Geography.
Journal of Soil and Water Conservation, Vol. 24, No. 4, p 144-147, August 1969.
4 fig.

Descriptors: *Soil erosion, *Erosion control, *Social aspects, Farm management, Land management, Soil conservation, Governments, Vegetation establishment, Water control, Cover crops.
Identifiers: *Jordan.

The way of life of the people in northern Jordan promotes continued misuse of the land and hinders the adoption of erosion control programs. In work completed thus far, attention has been almost exclusively concentrated on improving areas of land owned by the government. Relatively little consideration has been given to the improvement of agricultural practices which are, in the final analysis, the root cause of the erosion problem. The government's role in new programs should be confined to financing large capital projects, for example, dam construction, and intensifying research concerning the relative productivity of different agricultural patterns and crops. Villages should implement conservation at the local level under their own initiative. This will be difficult to instigate in a traditionally rural society.

68-69:02J-015
SEDIMENTATION IN THE NATION'S RESERVOIRS,
Dendy, Farris E.
Agricultural Research Service, Oxford, Mississippi.
Journal of Soil and Water Conservation, Vol. 23, No. 4, p 135-137, July-August 1968.
5 fig, 1 tab, 15 ref.

Descriptors: *Reservoir silting, Sediment yield, Reservoir storage, Trap efficiency.
Identifiers: Reservoir storage depletion.

Reservoir sedimentation data compiled by the U.S. Department of Agriculture Sedimentation Laboratory are summarized. The Nation's 968 reservoirs range from small ponds to over 1 million acre-ft. Annual average storage loss was 150,000 acre-ft, about 0.2% of initial total capacity, well within the design requirements of most reservoirs. Average depletion rates are much higher in reservoirs of 100 acre-ft or less, which account for only a small part of total reservoir capacity, but are 40% of the total number of reservoirs. Depletion was less than 1% for 58% of the reservoirs larger than 100,000 acre-ft, over 3% for 15% of the reservoirs, and in excess of 10% for only 2% of the reservoirs. Average sediment accumulation rates, in general, decrease as drainage area increases. Prediction of depletion rates can be successful only if local empirically determined relationships are used. The conclusions reached are that the depletion rate of 0.2% is not alarming, the 3% rate in small upland reservoirs seems excessive, and if present rates continue, about 20% of small reservoirs will be half filled with silt in 30 years.

68-69:02J-016
SMALL AMOUNTS OF SURFACE MULCH REDUCE SOIL EROSION AND RUNOFF VELOCITY,
Kramer, L. A., and Meyer, L. D.
Agricultural Research Service, Lafayette, Indiana.
Transactions of the American Society of Agricultural Engineers, Vol. 12, No. 5, p 638-641, September 1969. 8 fig, 2 tab, 15 ref.

Descriptors: *Erosion, *Rill erosion, Soil erosion, *Erosion control, Impact (rainfall), Slope stability, Runoff, Simulated rainfall, *Mulching, Water management (Applied).

This paper presents results of a study of various rates of surface mulch as they affect soil loss and runoff velocity under a broad range of degrees and lengths of slope. Tests were conducted under controlled laboratory conditions on two soil particle sizes composed of glass spheres averaging 33 and 121 microns in diameter. Erosion rate and runoff velocity were measured for a factorial set of the following treatment levels: mulch rate - equivalent to straw at 0, 1/8, 1/4, 1/2, and 1 ton per acre; slope steepness - 4, 6, 8, and 10 percent; slope length - equivalent to 40, 70, and 100 ft at a runoff rate of 1.5 in per hr. All treatment level combinations were tested randomly within each soil particle size group. The length of a test or run was 30 min., unless a very high erosion rate limited it to a shorter period. Compared with no-mulch conditions, mulch rates of 1/2 to 1 ton per acre greatly reduced the erosion rate and runoff velocity for a wide range of slope steepnesses and lengths. Lower mulch rates effectively reduced erosion of fine-sand size but not silt-size particles. Much of the effectiveness of a surface mulch application in reducing erosion and runoff velocity was lost when rilling, or flow under the mulch layer, occurred.

68-69:02J-017
CONTROLLING WATER EROSION WITH GRADED ROWS,
Carter, C. E., and Carreker, J. R.
Agricultural Research Service, U.S. Department of Agriculture.
Transactions of the American Society of Agricultural Engineers, Vol. 12, No. 5, p 677-680, September 1969. 4 fig, 5 tab, 7 ref.

Descriptors: *Erosion, Corn, Runoff, Agriculture, Rainfall.
Identifiers: Graded-row concept of controlling erosion.

Graded rows effectively controlled erosion from sloping loess soil. Measurements showed that graded rows reduced erosion 44 percent over non-graded rows, and during one series of storms, graded rows reduced erosion 78 percent over up-and-down-hill rows. Frequent row breakages, particularly on the steeper slopes, caused variation in the amount of erosion among slopes; however, during storms where no row breakover occurred, there was no significant difference between runoff or erosion and slope. Corn yield increased as slope steepness decreased.

SECTION VIII

WATER CYCLE - CHEMICAL PROCESSES (Group 02K)

68-69:02K-001
THE MOVEMENT OF RADIOACTIVE SODIUM AND RUTHENIUM THROUGH A SIMULATED AQUIFER,
Champlin, J. B. F., and Eichholz, G. G.
Georgia Institute of Technology, Atlanta.
Water Resources Research, Vol. 4, No. 1, p 147-158, February 1968. 8 fig, 20 ref.

Descriptors: *Groundwater, *Pollution, *Soils, Radioactivity, Aquifer, Sodium, Potassium, Calcium.

The interaction of water solutions with the particulate matter composing a natural aquifer is of steadily increasing interest with the new emphasis on pollution of our natural resources. As a means of studying the contribution made by water to the transport of ionic materials through soils, radioactive solutions were injected into a model aquifer containing 725 kg of sand with dimensions of 1x2x0.25 meters. As the radioactivity passed through the sand, its progress was followed by a collimated Geiger Muller tube situated on the exterior of the bed. The appearance of the radioactivity in the effluent, which marked the arrival of the sodium front, was found to be correlated with an increase in suspended particulate matter, potassium and calcium concentrations, and overall conductivity. Of particular significance was the portion of the radioactivity shown to be related directly to the filterable mass of particles in the effluent, despite the high solubility of the ion used. The results with the sodium were compared with those of similar tests on the movement of trivalent ruthenium, which is not soluble at the pH of the solutions used. Both the sodium and ruthenium studies indicated that a significant amount of radioactivity was transported through the test bed on particulate matter which was large enough to be trapped on 0.45 micron membrane filters.

68-69:02K-002
REDUCTION OF SULFATE TO SULFIDE IN WATERLOGGED SOIL,
Connell, W. E., and Patrick, W. H., Jr.
Louisiana State University, Alexandria, Dept of Agronomy.
Soil Science Society of America Proceedings, Vol. 33, No. 5, p 711-715, September-October 1969. 6 fig, 1 tab, 9 ref.

Descriptors: *Sulfate, *Sulfides, *Saturated soils, *Anaerobic conditions, Sulfur compounds, *Reduction, Soil chemistry, Oxidation-reduction potential.

A study was made of sulfate reduction to sulfide in waterlogged soils supplied with an energy source. Sulfate reduction was more rapid in surface soil than in subsurface layers with sulfide appearing 2 days after waterlogging samples of a surface soil. The amount of sulfide precipitated from added H_2S in two soils was approximately equivalent to the amounts of ferrous iron released by waterlogging. Added Fe_2O_3 was effective in precipitating H_2S. Sulfate reduction was retarded by nitrate. Addition of oxygen to highly reduced soils caused a rapid decrease in sulfide content, with one-half of the sulfide being oxidized in 15 minutes and all the sulfide oxidized after 8 hours.

68-69:02K-003
CROP SEEDLING UPTAKE OF DDT, DIELDRIN, ENDRIN, AND HEPTACHLOR FROM SOILS,
Beall, M. L., Jr., and Nash, R. G.
Agricultural Research Service, Beltsville, Maryland.
Agronomy Journal, Vol. 61, No. 4, p 571-575, July-August 1969. 4 tab, 24 ref.

Descriptors: *Insecticides, Pesticides, Residues, Absorption, Alfalfa, *Endrin, *DDT, Heptachlor, Crops.
Identifiers: Crop seedling.

In greenhouse experiments, soybean, wheat, corn, alfalfa, bromegrass, and cucumber seedlings took up various amounts of DDT, dieldrin, endrin, and heptachlor residues from five soils treated with 0.5 or 5.0 ppm insecticide. Residue concentrations in plants were usually well below the soil treatment rates, though endrin and heptachlor residues in alfalfa and bromegrass exceeded the treatment rate of some soils. The

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order of residue uptake in increasing amounts was DDT < dieldrin < endrin < heptachlor. Correlations calculated between residues in seedlings and several soil characteristics revealed that organic matter negatively affected the uptake of DDT, dieldrin, and heptachlor. Silt negatively affected endrin uptake. Soil moisture content at 0.33 bar tension negatively affected DDT and dieldrin uptake by alfalfa. No significant correlations were found between uptake and soil pH, cation exchange capacity, or clay content. Soil analysis, 14 or 20 months after insecticide application, revealed residues of the insecticides, in increasing order of persistence, to be heptachlor < dieldrin = endrin < DDT. Correlations calculated between residues in soils and the soil characteristics above revealed that persistence was positively correlated with soil organic matter.

68-69:02K-004
AVAILABILITY CHARACTERISTICS OF AND PLANT RESPONSE TO NITROGEN SOURCES,
McCants, C. B.
North Carolina State University, Raleigh, Dept of Soil Science.
Agronomy Journal, Vol. 61, No. 3, p 353-356, May-June 1969. 2 fig, 6 tab, 10 ref.

Descriptors: *Nitrogen, *Fertilizers, *Leaching, Tobacco, Moisture content, Ureas.
Identifiers: Nitrogen availability, Plant response to nitrogen, Controlled release fertilizers, Cottonseed meal.

The relative availability characteristics of nitrogen in urea, cottonseed meal, a commercial urea-formaldehyde product, and an experimental urea-wax material were studied through successive leachings in model lysimeters in the laboratory and by leaching and plant growth in the greenhouse. The effects of the nitrogen sources on yield and chemical composition of field-grown tobacco were studied under different moisture regimes. The total release of nitrogen from the urea-wax source was comparable to that from urea but significantly higher than from urea-formaldehyde or cottonseed meal sources. The rate of N release during the first 21 days was not different among the urea-wax, urea-formaldehyde, and cottonseed meal sources; thereafter, it was higher from urea-wax. When differences in crop response occurred among the different sources, the yield and quality index were higher from urea-wax than from cottonseed meal or urea-formaldehyde. These results and data from other research suggest that the probability of practical contributions of slow release fertilizers in the commercial production of annual field crops is quite small.

68-69:02K-005
EFFECT OF TIME AND METHOD OF NITROGEN APPLICATION AND SOURCE OF NITROGEN ON THE YIELD AND NITROGEN CONTENT OF CORN,
Stevenson, C. K., and Baldwin, C. S.
Ridgetown College of Agricultural Technology, Ridgetown, Ontario, Canada.
Agronomy Journal, Vol. 61, No. 3, p 381-384, May-June 1969. 6 tab, 11 ref.

Descriptors: *Ureas, Ammonium compounds, Nitrogen, Corn, Clays, Grains (Crops).

Fall plowdown, spring preplant, and side-dress applications of nitrogen were compared in field experiments on Brookston clay, Brookston clay loam, and Haldimand silt loam soils. Ammonium nitrate, urea, and anhydrous ammonia were compared at 56, 112, 168, and 224 kg N/ha. Spring application (preplant or side-dress) produced higher grain yields than fall application in all experiments regardless of the rate of nitrogen applied. Preplanting the nitrogen was as effective in increasing grain yield as the side-dress method. Yield results with fall-applied nitrogen were poorer on the clay soil than the loam soils. Spring application of nitrogen gave 370 to 2,610 kg/ha higher yield of corn grain than fall application on clay soils, and 200 to 1160 kg/ha higher yield of corn grain on the loam soils. No rate of nitrogen applied in the fall or in the spring. The nitrogen content of the grain varied with the time and method of application of nitrogen. Grain from plots that received nitrogen in the fall was markedly lower in percent nitrogen than grain from plots that received nitrogen in the spring.

68-69:02K-006
TRAVEL OF NITROGEN IN SOILS,
Preul, H. C., and Schroepfer, G. J.
Minnesota University, Minneapolis, Dept of Civil Engineering.
Journal of the Water Pollution Control Federation, Vol. 40, No. 1, p 30-48, January 1968. 15 fig, 5 tab, 6 ref.

Descriptors: *Adsorption, *Nitrogen, Saturation, Soils, Nitrification.
Identifiers: *Laboratory-scale studies.

A laboratory-scale study of the movement of nitrogen through soil showed that adsorption and biological action are the main controlling factors. Physical adsorption inhibits the travel of NH_4-N, but is limited by the presence of other ions. Little inhibition of NO_3-N occurs at wastewater pH. Adsorption dominates and biological interference with NH_4 movement is minimal when oxygen is limited, e.g., when soil is saturated. Under well-aerated conditions, nearly complete nitrification occurs within a few feet of the influent surface.

68-69:02K-007
THE RESPONSE OF MACROBENTHOS TO IRRIGATION RETURN WATER,
Kreis, Douglas, and Johnson, William.
Robert S. Kerr Water Research Center, FWPCA, Ada, Oklahoma.
Journal of the Water Pollution Control Federation, Vol. 40, No. 9, p 1614-1621, September 1968. 3 fig, 2 tab, 7 ref.

Descriptors: *Wastewater, *Mayflies, *Caddisflies, *Benthic, *Larvae, *Bloodworms, *Annelids, *Macrobenthos, *Irrigation return water.
Identifiers: Klamath River, California; Klamath River, Oregon; Lost River, California; Lost River, Oregon.

Macrobenthos communities of the Lost and Klamath Rivers of Oregon and California were surveyed to determine the response of benthic macroinvertebrates to irrigation return water. Lost River macrobenthos populations changed from associations of mayfly nymphs, and caddisfly and beetle larvae to associations of bloodworms and annelids. These changes were related to downstream increases in irrigation return water. Decreases in mayfly nymphs, caddisfly larvae, and scud populations, and increases in bloodworms and annelid populations, were noted downstream from a large agricultural drain in the Klamath River.

68-69:02K-008
LABORATORY AND FIELD TESTS OF POND SEALING BY CHEMICAL TREATMENT,
Sewell, John I.
Tennessee University, Knoxville, Dept of Agricultural Engineering.
Agricultural Experiment Station Bulletin No. 437, March 1968. 14 p, 4 fig, 5 tab, 4 ref.

Descriptors: *Seepage, *Permeability, *Reservoir leakage, *Reservoirs, *Darcy's Law, Lagoons, Ponds, Farm ponds, Water holes.
Identifiers: *Pond sealing.

Over 500 permeability tests with 8 soil-dispersing chemicals were conducted on 9 Tennessee soil types. Sodium pyrophosphate treatments at 2 and sodium carbonate (soda ash) at 5 tons per acre were the most successful. These treatments costing approximately $375 per acre for chemicals reduced the permeability of the 9 soils from 1/10 to 1/100 of the permeability of identical but untreated samples. Laboratory test results suggest that at least 1 ft. of well-compacted, relatively impervious seal blanket over porous areas of pond floors is necessary to prevent rupture of the seal blanket under 10-ft. heads. Nine seriously leaking ponds were treated according to the best procedures developed in the laboratory. Eight of these treated ponds held well; and between January 1 and November 15, 1967, the mean ratio of minimum to maximum pond depths was 0.74. One pond developed serious leaks which were successfully repaired to a pond depth of 6 feet. The field tests substantiated the laboratory tests in that chemical treatments can, for certain situations, be effective in reducing reservoir seepage.

68-69:02K-009
STEADY STATE STUDIES OF NITRIFICATION IN SOIL: THEORETICAL CONSIDERATIONS,
McLaren, Douglas A.
California University, Berkeley, Dept of Soils and Plant Nutrition.
Soil Science Society of America Proceedings, Vol. 33, No. 2, p 273-276, March-April 1969. 1 fig, 17 ref.

Descriptors: *Equilibrium, *Nitrification, *Soil chemistry, *Theoretical analysis, Nitrogen cycle, Nitrates, Nitrites, Ammonium.
Identifiers: Miscible displacement, Clynamics.

The author states that since, in nature, ammonia produced by microbial action or added as fertilizer is subjected to downward translocation; therefore, continuous flow laboratory columns would be more nearly representative of field conditions than reperfusion methods. Equations are set up for consecutive reactions in an idealized soil column and solved for concentrations of metabolites as functions of time and depth within the column under steady state conditions. The reactions of ammonium ion to nitrite ion to nitrate ion were so expressed for columns with maximum numbers of nitrifying organisms.

68-69:02K-010
INTERACTION OF PESTICIDES WITH NATURAL ORGANIC MATERIAL,
Wershaw, R. L., Burcar, P. J., and Goldberg, M. C.
Geological Survey, Denver, Colorado.
Environmental Science and Technology, Vol. 3, No. 3, p 271-273, March 1969. 3 fig, 1 tab, 9 ref.

Descriptors: *Pesticide kinetics, *Sorption, *Solubility, *Humic acids, DDT, 2, 4, 5-T, Leaching, Persistence, Pesticide residues, Soil, Soil chemical properties
Identifiers: Pesticide solubilization.

Sodium humate solubilizes DDT and humic acid strongly sorbs 2, 4, 5-T. The solubility of DDT in 0.5% sodium humate solution is at least 20 times its solubility in pure water. Solutions of 2, 4, 5-T of .0000121 g/ml and 0.1 N NaCl were mixed with humic acid. Adsorption data are shown graphically. Ion exchange may play a part in this sorption.

68-69:02K-011
THEORETICAL CONSIDERATION OF THE CALCIUM SULFATE-BICARBONATE-CARBONATE INTERRELATION IN SOIL SOLUTION,
Nakayama, F. S.
Agricultural Research Service, Phoenix, Arizona.
Soil Science Society of America Proceedings, Vol. 33, No. 5, p 668-672, September - October 1969. 5 fig, 2 tab, 13 ref.

Descriptors: *Thermodynamics, *Water chemistry, *Bicarbonates, *Carbonates, *Sulfates, Water quality, Aqueous solutions, Soil physical properties, Soil chemical properties, Gypsum, Reclamation, Soil water, Ions, Soil moisture, Acidity, Chemical potential.
Identifiers: *Ion-pairs distributions, Activity, Activity coefficients.

The probable distributions of the ion-pairs calcium-sulfate and calcium-carbonate and complex calcium bicarbonate ion in solution are discussed thermodynamically and graphically in terms of sulfate, carbonate, bicarbonate, and hydrogen ion activities. In alkali media where the carbonate form predominates, the calcium-carbonate species will dominate the calcium-sulfate and calcium-bicarbonate forms, and is a significant part of the total calcium in solution. The complexed and undissociated forms of Ca represent a significant portion of the total Ca in solution at equilibrium. Reclamation projects involving the improvement of soil physical and chemical properties using gypsum and other Ca sources require an understanding of these relationships.

68-69:02K-012
SULPHATE REDUCTION IN WATERLOGGED SOILS,
Bloomfield, C.
Rothamsted Experimental Station, Harpenden (England).
Journal of Soil Science, Vol. 20, No. 1 p 207-221, March 1969. 8 fig, 3 tab, 35 ref.

Descriptors: *Saturated soils, *Sulfates, *Water chemistry, *Biodegradation, *Sulfur bacteria, Anaerobic bacteria, Sulfides, Hydrogen sulfide, Organic matter.
Identifiers: Sulfate reduction, Desulfovibrio.

To study the factors that influence the release of free hydrogen sulfide, flooded soils were incubated with plant material and either sodium sulphate or elemental sulfur. Residual sulphate, FeS and hydrogen sulfide were measured throughout the reaction. Less free hydrogen sulfide was evolved from a periodically waterlogged soil than from a well-drained soil comparable HCl- and dithionite-soluble Fe content. With a readily soluble synthetic iron oxide as the source Fe, a slight excess of Fe

over the sulfate-equivalent sufficed to prevent loss of hydrogen sulfide. The native
organic matter in the well-drained Rothamsted top-soil seemed to have no effect in
promoting loss of hydrogen sulfide, but the FeS : hydrogen sulfide ratio was strongly
influenced by the nature of the plant material used as the source of energy. With
either sodium sulfate or S, considerably more free hydrogen sulfide was evolved with
lucerne than with rice blade. With S, the pH of the incubated mixtures was close to
that of the nominally S-free system, whereas with sodium sulfate the mixture became
quite alkaline. More free hydrogen sulfide was evolved under the more alkaline con-
ditions obtained with sodium sulfate, which suggests that it is the initial mobiliza-
tion of Fe that governs the distribution of the reduced S, rather than the pH-solu-
bility relations of FeS. An oxidized surface layer is very effective in retaining
sulphur in the soil.

68-69:02K-013
THE MEASUREMENT AND MECHANISM OF ION DIFFUSION IN SOILS,
Vaidyanathan, L. B., Drew, M. C., and Nye, P. H.
Oxford University, Soil Science Laboratory.
Journal of Soil Science, Vol. 19, No. 1, p 94-107, 1968. 8 fig, 1 tab, 12 ref.

Descriptors: *Diffusion, Potassium, Moisture content, Nutrients, *Approximation
method.
Identifiers: Impedance factor, Hydrogen resin paper.

Integral diffusion coefficients for K in two contrasting soils, containing different
levels of exchangeable K, are calculated from measurements of diffusive flux to a
hydrogen resin paper. The diffusion coefficients are larger, the higher the exchange-
able K level or moisture content. Diffusive flux of K in these soils can be account-
ed for entirely by diffusion through the soil solution in the pores. Impedance fac-
tors calculated compare satisfactorily with values for similar soils reported by
other workers. The concentration dependence of the diffusion coefficient is shown to
be causally related to the nature of the sorption isotherm. A method for estimating
the differential diffusion coefficient at any concentration is described. It can
also be calculated from the slope of the sorption isotherm at the chosen concentra-
tion, if the value of the impedance factor at the relevant moisture content is known
and if diffusion other than through solution only is negligible.

68-69:02K-014
A COMPARATIVE STUDY OF NITRIFICATION IN SOILS FROM ARID AND SEMI-ARID AREAS OF ISRAEL,
Etinger-Tulczynska, R.
Bacteriology Laboratory, Rehovot, Israel.
Journal of Soil Science, Vol. 20, No. 2, p 307-317, 1969. 10 tab, 16 ref.

Descriptors: *Nitrification, *Arid lands, *Subhumid climates, Nitrogen, Sodium com-
pounds, Ammonium compounds, Potassium compounds.
Identifiers: Israel, Chloromycetin, Nitrosomonas-Nitrobacter.

The influence of different factors on the nitrification of an added ammonium salt and
inherent soil-N in soils from arid and semi-arid areas of Israel was investigated.
Nitrification of ammonium-N proceeded rapidly at 28°C but was inhibited partially or
completely in soils incubated at 37-40°C. In contrast, nitrate formation from inher-
ent soil-N proceeded better at 37-40°C than at 28°C. Bacteriological examination
showed that a temperature of 37-40°C had an injurious effect on the population of
nitrifiers, especially the nitrate-forming bacteria. Nitrification by the Nitrosom-
onas-Nitrobacter group in culture media was also markedly inhibited at 37°C as com-
pared with that at 28°C. Chloromycetin at a concentration of 25 mg per 100 g soil,
and potassium chlorate at a concentration of 10^{-3}M, suppressed the formation of nit-
rate from ammonium-N more strongly than that from inherent soil-N. Marked differen-
ces in the two nitrification processes in the soils investigated provided good evi-
dence that the greater part of nitrate originating from soil-N is produced by some
process other than that which is responsible for nitrification of ammonium-N.

68-69:02K-015
PHOSPHORUS ADSORPTION SITES IN SOILS,
Harter, R. D.
Connecticut Agricultural Experimental Station, New Haven.
Soil Science Society of American Proceedings, Vol. 33, No. 4, p 630-632, July-August
1969. 3 tab, 10 ref.

Descriptors: *Phosphorus, *Soil properties, Organic matter, Aluminum, Iron.
Identifiers: *Extractable phosphorus.

Regression analysis of phosphorus adsorption as a function of five soil characteristics indicates that organic matter is important in the initial bonding of phosphorus by soils. It is, therefore, proposed that phosphorus is initially bonded to anion exchange sites on organic matter, and subsequently transformed into less soluble iron and aluminum phosphates.

68-69:02K-016

LYSIMETER STUDIES ON TRACER NITROGEN IN FOREST SOIL: I. NITROGEN LOSSES BY LEACHING AND VOLATILIZATION AFTER ADDITION OF UREA -N^{15},

Overrein, L. N.
Norwegian Forest Research Institute, Vollebekk, Norway.
Soil Science, Vol. 106, No. 4, p 280-290, 1968. 4 fig, 2 tab, 17 ref.

Descriptors: *Lysimeter, Nitrogen, Leaching Urea, Fertilizer, Physical properties, Forest soils.
Identifiers: Gas-sampling system.

A description is presented of a lysimeter system in combination with a gas-sampling apparatus, developed to study nitrogen transformations in 40 cm deep soil profiles with a natural stratification. This investigation deals with experiments on urea-N^{15} at rates from 100 to 1000 kg N/ha added to raw humus in lysimeters exposed to natural environmental conditions in a boreal forest. The analytical procedure includes determination of N_2, NO, N_2O, NO_2, and the isotope-ratio analysis of the respective gaseous components by analytical-preparative gas chromatography in combination with scanning mass spectrometry. The 12-week experimental period had a total precipitation of about 370 mm. During this time, the accumulated loss of nitrogen by leaching in the forest soil was slight, or even negative, at urea application rates less than 250 kg N/ha. The 1000 kg urea-N/ha treatment was followed by a leaching loss equal to 5 percent of the added fertilizer-N. The retention of urea-N reported is mainly attributed to processes involving the formation of non-leachable complexes of fertilizer-N and organic matter in raw humus. Urea added to raw humus induced losses of original humus nitrogen by leaching and volatilization. The higest total accumulated loss of ammonia was equal to 3.5 percent of added urea-N.

68-69:02K-017

NITROGEN, PHOSPHORUS, AND POTASSIUM INFLUENCE YIELD AND CHEMICAL COMPOSITION OF BLUEJOINT FORAGE,

Laughlin, W. M.
Agricultural Research Service, Palmer, Alaska, Crops Research Division.
Agronomy Journal, Vol. 61, No. 6, p 961-964, November-December 1969. 2 fig, 8 tab, 18 ref.

Descriptors: *Wheatgrasses, Alaska, Subarctic, Calcium, *Nitrogen, *Phosphorus, Boron, *Potassium, Manganese, Copper, Molybdenum, Cobalt, Fertilizers.
Identifiers: Barium, Alaska.

Field studies were conducted in the Matanuska Valley with bluejoint (Calamagrostic canadensis) from 1963-7 with annual applications of three N rates with and without P and K. N application increased dry-matter yields, N and Mg content, and N, P, and K uptake. N response increased each year when P was used. N decreased Ca, Al, B, Ba, and Dr concentrations. P application increased dry-matter yields, stand density, P, Ca, Mg, K, and Mn contents, and N, P, K, Ca, and Mg uptake and decreased the N percentage. K application increased dry-matter yield and K and Cu content only when P was used. K depressed Ca, Mg, Ba, B, Sr, and Zn contents. Native bluejoint responds favorably to N and K fertilization when adequate P is used.

68-69:02K-018

2, 4-D DIFFUSION IN SATURATED SOILS: A MATHEMATICAL THEORY,

Lindstrom, F. T., Boersma, L., and Gardiner, H.
Oregon State University, Corvallis.
Soil Science, Vol. 106, No. 2, p 107-113, 1968. 3 fig, 2 tab, 6 ref.

Descriptors: *Diffusion, *Saturated soils, *Chemicals, Clays, Organic matter, Herbicides, Soil water.

Identifiers: 2,4-D acid, pH.

A simple theory for describing the movement of chemicals in soil by diffusion is presented. An experimental procedure for measuring the value of the diffusion coefficient of the chemical and the retentive ability of the soil is described. The general applicability of this procedure is illustrated by determining coefficients for 2,4-D acid using nine different soils of varying pH, clay content, organic matter, and ion exchange capacity.

68-69:02K-019
STUDIES ON EXCHANGE OF SODIUM FROM SOILS BY LEACHING WITH CALCIUM SULFATE,
Chaudhry, G. H., and Warkentin, B. P.
McGill University, Quebec, Canada.
Soil Science, Vol. 105, No. 3, p 190-197, 1968. 4 fig, 4 tab, 17 ref.

Descriptors: *Sodium, *Leaching, *Calcium sulfate, Clays, Magnesium, Saturation.
Identifiers: Sodium-calcium exchange.

The exchange of sodium from soils and clay minerals was studied by leaching columns of the materials with calcium sulfate. The exchangeable sodium percentage was rapidly reduced to 5 to 10 percent; further reductions were slow and required large amounts of leaching solution. After sodium no longer appeared in the leachate, from 3 to 6 percent exchangeable sodium remained on the clay. Complete replacement of sodium by leaching was not possible. Replacement of magnesium did not begin until the rapid exchange of sodium was completed. Differences in solute mixing among the different clays were more important than differences in sodium-calcium exchange constants, resulting in an efficiency of replacement in the order: attapulgite > kaolinite > halloysite >> illite > montmorillonite. The initial rapid exchange of sodium led to a uniform concentration of sodium remaining where less than symmetry amounts of calcium were used.

68-69:02K-020
FIXATION OF ATMOSPHERIC NITROGEN BY NON-LEGUMES IN WET MOUNTAIN MEADOWS,
Porter, L. K., and Grable, A. R.
Agricultural Research Service, Fort Collins, Colorado.
Agronomy Journal, Vol. 61, No. 3, p 521-523, May-June 1969. 1 fig, 5 tab, 8 ref.

Descriptors: *Nitrogen, *Irrigation, Organic matter, Legumes, *Grasslands, Water tables, Microorganisms.
Identifiers: *Moutain meadows, Nonlegumes.

Mountain soils subjected to excessive irrigation and high water tables accumulate organic matter in sod mats. Meadow soils often contain two or three times more N than equal areas of adjacent dry soils. Symbiotic nitrogen fixation by legumes is one possible source of N for sod mat formation. Fixation of N_2 by free-living organisms has also been posculated and was verified by the laboratory studies reported here. Nitrogen fixation by sod mats containing no legumes was determined at 18°C in atmospheres containing N_2^{15}. Both photosynthetic and nonphotosynthetic organisms appeared to fix N_2. In 10 days, mats in the dark fixed from 0.76 to 1.90 kg N_2^{-1} and illuminated mats fixed from 3.72 to 6.86 kg N ha^{-1}.

SECTION IX

WATER SUPPLY AUGMENTATION AND CONSERVATION

SALINE WATER CONVERSION (Group 03A)

68-69:03A-001
ECONOMIC FRAMEWORK FOR SALINITY CONTROL PROJECTS,
Coffey, Philip J., and Ortolano, Leonard.
Harvard University, Cambridge, Massachusetts.
Journal of the American Water Works Association, Vol. 61, No. 5, p 237-241, May 1969.
2 fig, 2 tab, 16 ref.

Descriptors: *Salinity, *Water pollution control, *Economic justificatinn, Cost-benefit analysis, Mathematical models, Marginal benefits, Marginal costs, Dissolved solids, Water users, River flow, Optimum development plans, Water management (Applied).
Identifiers: Differential equations, Graphical methods.

A systematic approach for finding the optimal level and type of salinity control on a river was presented, and a hypothetical example demonstrated its use. The objective was to determine the minimum total pollution cost, which was the sum of upstream control costs (a decreasing function of downstream residual salinity), and downstream users costs (an increasing function of salinity). Differential equations of cost as a function of total dissolved solids were derived and solved. The necessary first and second order conditions for cost minimization or benefit maximization were obtained. A graphical method was presented which extrapolated between four possible treatment levels. The method can be applied in situations where the level of water use is static.

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SECTION X

WATER SUPPLY AUGMENTATION AND CONSERVATION

WATER YIELD IMPROVEMENT (Group 03B)

68-69:03B-001
LIQUID-LIMIT DETERMINATION FOR INDICATING EFFECTIVENESS OF CHEMICALS IN POND SEALING,
Sewell, J. I., and Mote, C. R.
Tennessee University, Knoxville, Dept of Agricultural Engineering.
Transactions American Society of Agricultural Engineers, Vol. 12, No. 5, p 611-613,
September-October 1969. 6 fig, 3 tab, 6 ref.

Descriptors: Ponds, *Soil sealants, Seepage, *Permeability, Dispersing agents, *Liquid limits, Reservoirs, Plasticity index, Reservoir leakage, Soils, Soil properties, Soil mechanics.
Identifiers: Soil pasticity, *Seepage control, Permeability tests, Canal sealants, Sodium carbonate, Sodium phosphates, *Chemical sealants.

Rapid and accurate methods are needed for selecting chemical pond sealers and determining application rates for a given soil. A probably satisfactory method involves running standard constant-head permeability tests on treated soil samples, but considerable laboratory equipment may be required and at least 30 days delay to reach steady-state permeameter discharge rates may be necessary. A quicker and simpler method for evaluating chemical treatment of some soils would be determining the decrease in liquid-limit from chemical treatment. Chemical dispersing agents used as pond sealers break soil aggregates into finer particles, reduce soil permeability, and increase fluidity of the soil-water system; and determination of liquid-limit is a method for measuring changes in the fluidity of the soil-water system. Laboratory tests made on 7 Tennessee soils treated with sodium carbonate and sodium pyrophosphate evaluated the accuracy of liquid-limit as a measurement of permeability. Results showed liquid-limit correlation with permeability for 5 plastic soils, and no correlations for a soil of plasticity and a soil of low plasticity.

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WATER SUPPLY AUGMENTATION AND CONSERVATION

USE OF WATER OF IMPAIRED QUALITY (Group 03C)

68-69:03C-001
SOME EFFECTS OF HIGH SALINITY ON GERMINATION AND EMERGENCE OF BARLEY,
Donovan, T. J., and Day, A. D.
Arizona Agricultural Experiment Station, Tucson.
Agronomy Journal, Vol. 61, No. 2, p 236-238, March-April 1969. 3 tab, 9 ref.

Descriptors: *Salinity, *Barley, *Plant growth, *Salt tolerance, *Germination, Arid lands, Soil-water-plant relationships, Saline soils, Seeds, Plant physiology, Arizona, Saline water.
Identifiers: Emergence (Seedlings).

Salinity frequently limits crop production in arid and semiarid agricultural regions. Thirty-nine barley varieties and lines were germinated in distilled water and in a water and sandy loam culture salinized to various concentrations. Most commercial varieties of barley had lower germination rates than did California Mariout and several saline tolerant strains developed by the USDA. Emergence in salinized soils was comparable to germination in water solutions. At moderate salinity levels most of the barleys performed well. At high salinity only the California Mariout and the salt tolerant strains were satisfactory. All the barleys were delayed in emergence in the highly saline media. In saline areas, tolerant barleys should be used, or if irrigation practices permit maintenance of low salinity during germination, higher salinity at later stages may not greatly affect yields. Laboratory methods are useful in screening barley varieties but should be supplemented by field trials.

68-69:03C-002
QUALITY OF WATERS FROM PLAYAS ON THE SOUTHERN HIGH PLAINS,
Lotspeich, Frederick B., Hauser, Victor L, and Lehman, Oliver R.
Agricultural Research Service, Bushland, Texas.
Water Resources Research, Vol. 5, No. 1, p 48-58, February 1969. 8 fig, 5 tab, 16 ref.

Descriptors: *Water quality, *Water chemistry, *Playas, *Surface runoff, *Texas, Runoff, Water storage, Groundwater, Aquifers, Salts, Nitrates, Hydrogen ion concentration, Electricalconductance, Watersheds (Basins), Dissolved solids, Sodium.

It is estimated that 2.5 to 3.0 million acre-feet of surface runoff accumulate annually in the thousands of playas that dot the southern High Plains. Most of this water is wasted by evaporation, but much of it could be conserved by storage in the aquifer. However, past lack of knowledge about its quality has impeded progress. A study was conducted to determine the quality of water from 13 playas in an area extending about 100 miles from northeast to southwest and covering two major soil types. The change in water quality with time was also determined. Playa water contained less salts than groundwater and was of excellent quality for irrigation. Nitrate contents were less than 1.0 mg/liter in nearly all playas. Almost no nitrogen applied as fertilizer was washed into playas by runoff water. High and variable amounts of suspended solids contained in playa waters were substantially reduced by settling in deep reservoirs protected from wind and wave action.

68-69:03C-003
SODIUM HAZARD OF IRRIGATION WATERS AS INFLUENCED BY LEACHING FRACTION AND BY PRECIPITATION OR SOLUTION OF CALCIUM CARBONATE,
Bower, C. A., Ogata, G., and Tucker, J. M.
Agricultural Research Service, Riverside, California.
Soil Science, Vol. 106, No. 1, p 29-34, July 1968. 4 fig, 5 tab.

Descriptors: *Sodium, *Irrigation water, *Leaching, *Chemical precipitation, *Calcium carbonate, Hydrogen ion concentration, Lysimeters, Alfalfa, Salinity, Loam, Adsorption, Cation exchange, Drainage water, Calcium, Magnesium.
Identifiers: Leaching fraction, Steady state values.

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Calcareous Pachappa sandy loam in lysimeters growing alfalfa was irrigated with six waters having variable Na/(Ca + Mg) and HCO3/(Cl=SO4) ratios at leaching fractions of .1, .2, .3, and .4, until the sodium adsorption ratio of the drainage water became constant. Increased leaching repressed precipitation of CaCO3 from the waters and enhanced solution of CaCO3 from the soil. At any leaching fraction, the amount and fraction of applied HCO3 that precipitated as CaCO3 from the water or the amount of CaCO3 that dissolved from the soil was highly related to a calculated pH value of the water which was dependent primarily upon the Ca, Mg, and HCO3 concentrations of the water. When the sodium-adsorption ratio of the drainage waters from the lysimeters had become constant, the salt and exchangeable Na that had accumulated in the soil increased with depth.

68-69:03C-004
PEANUT RESPONSE TO UNIFORM AND NON-UNIFORM SOIL SALINITY.
Shalhevet, J., Reiniger, P., and Shimshi, D.
National and Univ. Inst. of Agriculture, Rehovoth (Israel), Volcani Inst. of Agriculture Research.
Agronomy Journal, Vol. 61, No. 3, p 384-387, May-June 1969. 3 fig, 3 tab, 5 ref.

Descriptors: *Peanuts, *Saline soils, *Plant growth, *Crop response, *Crop production, Arid lands, Irrigation, Evapotranspiration, Adsorption, Germination, Growth stages, Seeds, Plant physiology, Salinity, Salt tolerance, Soil profiles.
Identifiers: *Soil salinity, *Water uptake, Israel.

Peanuts grown in artificially salinized plots showed a 50 percent yield reduction at an EC sub e of 4.7 mmhos/cm and a 20 percent reduction at an EC sub e of 3.8 mmhos/cm. As long as there was equal mean soil salinity, the shape of the soil salinity profile did not affect yield reduction. As salinity increased, total ET decreased, but it would appear that the reduction in water uptake resulting from increased soil salinity was the consequence of reduced growth, rather than the cause of it. The decrease in ET efficiency at high salinity levels was due not to transpiration, but to evaporation from plots having an incomplete plant cover. Salt tolerance was higher during germination than during any subsequent growth stage. At an EC sub e of 13 mmhos/cm a 50 per cent reduction in germination was obtained. There was a similar 50 percent reduction in seedling development at an EC sub e of 7.2 mmhos/cm.

68-69:03C-005
EXPERIMENT IN THE LEACHING OF SALINE LAND IN SOUTHERN KAZAKHSTAN,
Kalinin, Ya. D.
Soviet Hydrology: Selected Papers, Issue No. 2, p 201-209, 1969. 2 fig, 8 tab, 7 ref.
Translated from Hydraulic Engineering and Reclamation (Gidrotekhnika i melioratsiya), No. 8, p 66-75, 1969.

Descriptors: *Leaching, *Saline soils, *Land reclamation, *Irrigation, Drainage, Irrigation effects, Irrigation practices, Salinity, Salt balance, Soil management.
Identifiers: *USSR, *Kazakhstan.

Saline lands in Kazakhstan were leached for the first time over a large area (1100 hectares) at state farm No. 1, located in the area of the Arys'-Turkestan irrigation system (northwestern part of Chimkent Province). The site of this irrigation system is between the gently sloping piedmont plain of the Kara-Tau Ridge and the old alluvial plain of the Syr-Dar'ya River. The elevations of this area are 200-240 m and the slopes, 0.001-0.006. The mean annual precipitation is 184-210 mm with a weak maximum in the winter-spring period. The mean annual air temperature is 12-12.7 deg C. The frost-freeperiod lasts 195 days with a mean daily temperature sum of 4300 deg C. The average annual relative air humidity is 53% and evaporative power reaches 1500 mm per year. Prior to leaching, a salt survey was performed. It was found that of the total area of the irrigated area, 38.6% was saline, including 29.8% with soil salinity ranging from 0.7 to 3.0%. The permissible residual salinity after leaching was found to be 0.3-0.4% with allowance for the composition of the initial salts. Leaching removed 145,000 metric tons of salts (69%), including 29,300 metric tons of the chloride ion (96%), from the upper meter of the soil, originally containing 211,000 metric tons of salt.

SECTION XII

WATER SUPPLY AUGMENTATION AND CONSERVATION
CONSERVATION IN DOMESTIC AND MUNICIPAL USE (Group 03D)

68-69:03D-001
CONSERVATION OF WATER IN AGRICULTURE, INDUSTRY, AND MUNICIPAL USE,
Ackerman, Edward A.
Carnegie Institution of Washington, Washington, D.C.
Water Resources Bulletin, Vol. 4, No. 1, p 3-20, March 1968. 4 fig, 1 tab.

Descriptors: *Water conservation, Pesticides, Sediments, *Hydrologic cycle, Meteoric water, Evaporation, Evapotranspiration, Precipitation (Atmospheric), Quality control, *Water management (Applied), Decision making, *Agricultural chemicals, Waste disposal, Planning, Social values, Communication, Aesthetics, Pollutants.
Identifiers: *Atmospheric reservoir, *Quality conservation, *Water supply, Biosphere, Development, Urban impact, Recycle.

Factors to be considered in planning research and development are related to water conservation practices. Effective conservation lies in recognition by policy leadership of the following: (1) water problems are not divisible; (2) effective water management means integrated management; and (3) future conservation actions must be based on broad and effective public communication. A conservation system, including man and his environment, is described as a variant of the hydrologic cycle. Maintenance of water quality is as important as conserving quantity; pollution control, as a part of conservation, is being increasingly recognized and attacked in urban and industrial areas. The more difficult problem of agricultural pollution by sediment, leached salts, pesticides, and other sources is receiving more attention. Objectives for water quality conservation are presented: (1) the traditional approach which stresses natural waste disposal functions of streams but does not consider aesthetic and other values; and (2) a new approach which proposes that water as a part of the human environment, like air, should be as clean as we can make it. Integrated planning and development is a central objective.

SECTION XIII

WATER SUPPLY AUGMENTATION AND CONSERVATION

CONSERVATION IN AGRICULTURE (Group 03F)

68-69:03F-001
DESIGN OF AN AUTOMATED SURFACE IRRIGATION SYSTEM WITH REUSE SYSTEM,
Fischbach, Paul E.
Nebraska University, Lincoln.
Paper, American Society of Civil Engineers National Irrigation & Drainage Specialty Conference, Phoenix, Arizona, p 219-236, November 1968. 10 fig, 7 ref.

Descriptors: Automatic control, Automation, *Irrigation systems, Field tests, *Irrigation design, *Water reuse, *Surface irrigation, Hydraulic gates and valves, Land forms, Slopes, Furrow irrigation, Pumping plants, Furrows, Irrigation, Tensiometers, Control systems, *Irrigation canals, Gate control.
Identifiers: Reuse.

Design and component features for an automatic surface irrigation system with provision for reuse of runoff water are described. Requirements for the system are: a supply of water available on demand; an enclosed pipe system designed to carry water from the source to the point of release for irrigation; a method of sequencing irrigation sets; control of the water flowing over the land surface; a runoff collection and return system; soil moisture sensing devices that sense the need for water to start and stop the system; and electrical controls. Land forming, row direction, furrow stream size, length of run, and application time are discussed. To test and evaluate the theories propounded, an automatic surface irrigation system with runoff water reuse was operated for 3 seasons at the University of Nebraska field laboratory Mead, Nebraska. The system is described and results are discussed.

68-69:03F-002
AUTOMATION OF SURFACE IRRIGATION SYSTEMS,
Haise, Howard R., and Kruse, E. Gordon.
Agricultural Research Service, Fort Collins, Colorado.
Proceedings National Irrigation and Drainage Specialty Conference, ASCE, Phoenix, Arizona, p 175-200, November 13-16, 1968. 13 fig, 9 ref.

Descriptors: *Surface irrigation, *Turnout gates, *Laterals, Automatic control, Water distribution.
Identifiers: *Fluidic diverters, *Water-powered cylinders, *Center pivot gates, Float valves.

Two systems for automating surface irrigation are described. One uses pneumatic valves remotely controlled by tone telemetry to open and close turnouts at timed intervals. The other uses water-powered cylinders activated by float valves to operate center pivot gates. Large fluidic diverters have also been evaluated for irrigation applications. The automation components can be adapted to furrow, border, dike, and basin irrigated fields supplied by open ditches or buried pipelines. Several field systems have been installed and evaluated.

68-69:03F-003
A HYDRODYNAMIC DETERMINATION OF CUTBACK STREAM SIZES OR IRRIGATION FURROWS,
Wilke, O. C., and Smerdon, E. T.
Florida University, Gainesville, Dept of Agricultural Engineering.
American Society of Agricultural Engineers Transactions, Vol. 12, No. 5, p 634-637, September-October 1969. 11 fig, 10 ref.

Descriptors: *Hydrodynamics, *Flow, *Furrows, *Furrow irrigation, *Irrigation engineering, Irrigation design, Channels, Streamflow, Runoff, Water management (Applied), Equations, Water loss, Infiltration, Mathematical models, Volume, Wetting, Application methods.
Identifiers: *Cutback, *Cutback sizes, Steady state.

In order to avoid runoff losses, the stream should be reduced after the wetting front nears or reaches the end of the furrow. Two methods of determining the required cutback size are volume balance analysis and numerical integration of the steady state

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equations of motion for shallow flow. These two methods were studied and graphic design relationships presented. Good field verification of the volume balance method was achieved, but more experimentation should be conducted. It would then be possible to design an automated cutback system which could apply water uniformly without runoff losses.

68-69:03F-004
WIND VARIATION AND SPRINKLER WATER DISTRIBUTION,
Seginer, I.
Technion, Haifa, Israel, Dept of Agricultural Engineering.
Journal of the Irrigation and Drainage Division, American Society of Civil Engineers, Vol. 95, No. IR2, p 261-274, June 1969. 10 fig, 4 tab, 5 ref.

Descriptors: *Irrigation, Sprinkler irrigation, Wind velocity, Water distribution (Applied).

The superimposed distribution pattern of a moving sprinkling lateral is not equal to that of a solid set employing the same sprinklers, whenever wind variations occur between positions of the lateral. Variations perpendicular to the lateral have the most significant effect, resulting in convergence or divergence of two adjacent patterns. The uniformity coefficient increases (improves) and the mean depth of water increases with increased convergence. The effect on the uniformity coefficient is more pronounced as the spacing between lateral positions increases. For every wind regime there is an optimum direction of the laterals for which the overall uniformity is highest.

68-69:03F-005
SAVE THAT WATER,
Patterson, P. M.
Irrigation Age, p 16-19, March 1970.

Descriptors: *Irrigation practices, *Irrigation, Irrigation design, *Irrigation efficiency, Water delivery, Water distribution (Applied), *Water reuse, *Irrigation engineering, Management.
Identifiers: Texas High Plains, *Tailwater return system.

Tailwater loss and tailwater return systems have been the subject of intensive study in the Texas High plains for the past several years. These studies began in 1963 and were conducted by the High Plains Underground Water Conservation District in Lubbock. Studies indicated that on the average, 20 percent of the water being pumped will be lost without a tailwater return system. Representatives of underground water conservation districts will design tailwater return system on request of the farmer. The following information is needed for design: (1) number of wells contributing to tailwater; (2) size of wells; (3) number of acres irrigated by contributing wells; (4) slope of the land; (5) type of soil. Examples of the costs and benefits of tailwater systems currently in use in the Texas High Plains area are given.

68-69:03F-006
THE CLIMATE OF THE COTTON CROP: PHYSICAL CHARACTERISTICS AND MICROCLIMATE RELATIONSHIPS,
Stanhill, G., and Fuchs, M.
Volcani Institute of Agricultural Research, Rehovoth, Israel.
Agricultural Meteorology, Vol. 5, No. 3, p 183-202, May 1968. 9 fig, 5 tab.

Descriptors: *Cotton, *Climatic data, *Irrigation effects, Humidity, *Microclimatology, Air temperature, Growth stages, Semiarid climates, Energy budget, *Crop response, Vapor pressure, Wind velocity, Albedo, Water loss, Hygrometry, Soil temperature, Anemometers, Solar radiation, Heat.
Identifiers: *Aerodynamics, *Energy balance, Israel, Solar elevation, Physical characteristics, Heat storage.

A study of the radiative and aerodynamic characteristics of two irrigated cotton crops was made in a semi-arid zone of Israel. Some of the physical characteristics of the irrigated cotton crop of importance in the modification of the crop microclimate were studied and the relationship between the climate over the crop and that measured at an adjacent open site were determined. Air temperature was always less and humidity greater at the irrigated crop than over the bare soil. Results obtained were compared with those previously reported in the literature for this crop in order to see to what extent they may be considered as being of general application. Microclimate is a factor of great importance in determining yield and water loss from agricultural crops.

68-69:03F-007
HANDLING WATER BY COMPUTER,
McMullin, R. J.
Salt River Project, Arizona.
Reclamation Era, Vol. 55, No. 3, p 14-17, August 1969.

Descriptors: *Water delivery, Water supply, *Computers, Data processing, *Irrigation water, Water rights, Irrigation.
Identifiers: Salt River Project.

A description is given of the computer system used for managing waters supplied in the Salt River Project. The two system/360 central processing units at the project administrative headquarters are connected to 15 remote 1050-type communications terminals. The teleprocessing network enables employees in the project field offices to promptly and efficiently fill orders for irrigation water. The central master file contains the water rights for each acre of land, an updated record of each water account, and an accounts receivable record. The computer is used to furnish water to subdivision lots and handle the billings. The system is also used for billing electricity accounts.

68-69:03F-008
EFFECT OF IRRIGATION AND CLIPPING ON SEED PRODUCTION AND CHASMOGAMY OF SERICEA GENOTYPES,
Donnelly, E. D., and Patterson, R. M.
Auburn University, Alabama, Dept of Agronomy and Soils.
Agronomy Journal, Vol. 61, No. 4, p 501-502, July-August 1969. 2 tab, 13 ref.

Descriptors: *Seeds, Irrigation, Agriculture, Forages.
Identifiers: Cleistogamous, Lespedeza cuneata, Seed yield, Clipping.

Seed yield and proportion of chasmogamous seed as affected by irrigation and clipping were determined for 18 lines of sericea, Lespedeza cuneata. Seed yields were increased by irrigation regardless of clipping management; however, irrigation did not increase the percentage of chasmogamous seed. Clipping in June drastically reduced seed yield and percentage of chasmogamous seed. Irrigation of clipped sericea further reduced chasmogamous seed percentage below that of nonirrigated clipped sericea. Lines reacted differently to irrigation and clipping both as to proportion of seed types and seed yield.

68-69:03F-009
INFLUENCE OF IRRIGATION INTERVAL AND PLANT DENSITY ON ALFALFA SEED PRODUCTION,
Abu-Shakra, S., Akhtar, M., and Bray, D. W.
Beirut American University, Beirut, Lebanon, Faculty of Agricultural Sciences.
Agronomy Journal, Vol. 61, No. 4, p 569-571, July-August 1969. 1 tab, 6 ref.

Descriptors: *Irrigation.
Identifiers: Components of seed yield, Hairy Peruvian plants.

Irrigation applied once every 2 weeks, providing a seasonal total of 25.7 cm of water, produced the greatest seed yield, as well as an increase in the number of pods per raceme, number of seeds per pod, and 1,000-seed weight. Plants irrigated at 3 or 4-week intervals produced the highest number of hard seeds. The 50 x 50 cm plant spacing produced well developed alfalfa plants which gave relatively high seed yields of 80 kg/dunum (1,000 m^2) in 1966 and 65 kg/dunum in 1967. The variety 'Hairy Peruvian' produced more pods per raceme and more seeds per pod resulting in greater seed yield than that from the varieties 'African' and 'Chilean.' The Hairy Peruvian plants were the shortest of the three varieties grown.

68-69:03F-010
INFLUENCE OF SALINITY ON GERMINATION, VEGETATIVE GROWTH, AND GRAIN YIELD OF RICE (ORYZA SATIVA VAR. DULAR),
Narale, R. P., Subramanyam, T. K., and Mukherjee, R. K.
Indian Institute of Technology, Kharagpur, India.
Agronomy Journal, Vol. 61, No. 3, p 341-343, May-June 1969. 4 fig, 1 tab, 11 ref.

Descriptors: *Salinity, *Electrical conductivity, Germination, Rice, Seeds,
Identifiers: Toxic effect, *Osmotic effect.

An experiment in Petri dishes with filter paper beds using saline solutions of different electrical conductivities (ECe) obtained by dissolving common salt in distilled water to study their influence on rice seed germination, and a soil culture experiment with different levels of induced salinity under greenhouse conditions to study the effect of salinity on vegetative growth and grain yield of rice, were carried out. 'Dular,' a local variety of rice, was used as the experimental material. Rice seeds could germinate normally in medium of ECe up to 4.5 mmho/cm. Seed germination, which began to be adversely affected from ECe of 8.9 mmho/cm onwards, could, however, be initiated to some extent by transferring the treated seeds to distilled water. Grain yield and vegetative growth were markedly hampered at ECe of 7.2 and 9.8 mmho/cm, respectively.

68-69:03F-011
EVAPOTRANSPIRATION REDUCTION,
Gangopadhyaya, M., and Venkatoraman, S.
Meteorological Office, Poona, India.
Agricultural Meteorology, Vol. 6, p 339-345, 1969. 2 fig, 1 tab, 4 ref.

Descriptors: *Evapotranspiration, *Transpiration control, *Soil water movement, *Monomolecular films, Water yield improvement, Stomata, Water loss, Plants, Irrigation, Evaporation control.
Identifiers: OED green phenyl mercuric acetate.

Preliminary small scale trials on some of the field problems involved in the chemical reduction of evapotranspiration losses were carried out. It was seen that initial mixing of the top layer of the soil with OED green gave economically worthwhile reductions in evaporation from a freely drained periodically irrigated soil surface. Spraying of OED green initially on a wet soil surface appeared to be promising. Trials on paddy showed that: (1) monomolecular films of petroleum ether did not have any harmful contact effects on the crop; (2) the effect of phenyl mercuric acetate on young plants disappeared with the emergence of a fresh flush of foliage; and (3) a combination of phenyl mercuric acetate and OED green was more effective but toxic.

68-69:03F-012
SCHEDULING IRRIGATIONS WITH COMPUTERS,
Jensen, M. E.
Agricultural Research Service, Kimberly, Idaho.
Journal of Soil and Water Conservation, Vol. 29, No. 5, p 193-195, September-October 1969. 1 fig, 2 ref.

Descriptors: *Irrigation, *Cost, *Computers, *Management, Climate, Statistics, Value, Data collections, Rainfall, Soil analysis, Precipitation, Farming, Optimization, Evaporation, Programs, Data processing.
Identifiers: *Irrigation scheduling, Time sharing.

The author seeks to show how irrigation scheduling using climate-crop-soil data and computers can facilitate the tedious computations usually accompanied by field observations. This service, which includes the field work of experienced personnel, is shown to be an economically justified management service which increases the management skills of the farmer at a reasonable cost. The background of its development is traced and the basic principles involved are explained. The cost of the service is found to be a hinderance to its adaptation on small farms but posing no problem for large acreages.

68-69:03F-013
OPTIMAL TIMING OF IRRIGATION,
Hall, Warren A., and Butcher, William S.
California University, Riverside, Dept of Engineering.
Journal of the Irrigation and Drainage Division, American Society of Civil Engineers, Vol. 94, No. IR2, Proc. Paper No. 5993, p 267-275, June 1968. 3 ref, 2 append.

Descriptors: *Irrigation efficiency, *Timing, *Dynamic programming, *Optimization, Yield equations, *Mathematical models, Water supply, Irrigation water, Analytical technique, Rates of application, Growth stages, Cost-benefit analysis, Water distribution, Supplemental irrigation.

A methodology was derived permitting determination by dynamic programming of the optimal timing of irrigation, to produce the greatest net return inclusive of the cost of irrigation. It was particularly useful under conditions in which seasonal supply was inadequate but reasonably predictable. The analysis was based on the principle that the adverse effects of deficiencies (nutrition, excessive salinity and soil moisture) were geometric when existing in combination. For general use, additional data concerning the yield coefficients will be required covering each of the critical stages in the growth of the crops independently.

68-69:03F-014
MANAGEMENT: A KEY TO IRRIGATION EFFICIENCY,
Erie, Leonard J.
Agricultural Research Service, Phoenix, Arizona.
American Society of Civil Engineers Proceedings, Journal of the Irrigation and Drainage Division, Vol. 94, No. IR3, Paper No. 6107, p 285-293, September 1968. 2 fig, 4 tab, 10 ref.

Descriptors: *Water management (Applied), *Irrigation practices, *Water consumption (Plants), *Water loss, Evapotranspiration, Water utilization, Soil-water-plant relationship, Conservation.
Identifiers: *Irrigation efficiency, Crop irrigation.

Water consumption and efficiency of crop irrigation are discussed with relation to management. Water losses that occur in transporting from sources to ultimate irrigation sites are described, and some unavoidable water losses in management procedure are identified. Comparisons are made between various water uses, particularly those in industry and agriculture, and consumptive use data are discussed relative to conservation. Because irrigated agriculture accounts for 80% or more of all water consumed in the U.S., the greatest opportunity for water conservation exists in good irrigation management. About 60% of the water withdrawn for irrigation is lost through evapotranspiration, and another large percentage is not otherwise beneficially used by plants. Inefficient application occurs because of lack of knowledge about soils, root systems, and consumptive use estimates by the manager.

68-69:03F-015
SOIL WATER RECHARGE DURING THE DORMANT PERIOD IN THE NORTHWEST CORN BELT,
Timmons, D. R., and Holt, R. F.
Agricultural Research Service, Morris, Minnesota.
Journal of Soil and Water Conservation, Vol. 23, No. 5, p 177-180, September-October 1968. 5 fig, 2 tab, 12 ref.

Descriptors: *Recharge, *Soil moisture, *Prairie soils, South Dakota, Minnesota .
Identifiers: Dormant season (Crops), Farming.

Soil water recharge during the dormant period was measured for several crops at 17 locations in western Minnesota and eastern South Dakota during a 3-yr. period. The experimental areas were on prairie soils developed on calcareous glacial till or on loess overlying till. Annual precipitation is 21-25 inches, of which 10-12 are available for recharge. Soil water content at the beginning of the dormant period is a major factor in determining dormant season recharge. The greatest increase in total soil water generally was in late March and early April when precipitation was rain and wet snow and the soil was thawing. Between freeze and thaw, 49% of precipitation was retained by the soil. Spring recharge was 29% of precipitation and was lowest where initial soil moisture was highest.

68-69:03F-016
FUTURE IRRIGATION DEMAND IN THE SUSQUEHANNA BASIN,
Miller, Howard.
Chesapeake Bay-Susquehanna Rivers Basins Project, Susquehanna Field Station.
American Society of Civil Engineers Proceedings, Journal of the Irrigation and Drainage Division, Vol. 94, No. IR4, Paper No. 6278, p 391-399, December 1968. 2 fig, 8 tab, 2 ref.

Descriptors: *Irrigation, *Forecasting, *Water utilization, Pennsylvania, New York, Low flow, Droughts, Water loss, Water resources, Water supply, Seepage.
Identifiers: Susquehanna River Basin.

Some years hence, during drought years, irrigation probably will have significant and locally detrimental effects on the surface water economy of the Susquehanna Basin, that is, barring changes in water laws or watershed development projects. Support for the theory that practice of irrigation will grow comes from an analysis of rainfall frequency and crop production deficiencies in drought years. From this, average annual profit per acre can be estimated. From designs of irrigation systems under a range of conditions, annual costs per acre can be estimated. By logic, it can be assumed that crops with the greatest profit potential will be irrigated in the future. Tempering the synthetic predictions with consideration of current irrigation practice and trends, predictions of future irrigation withdrawals are made. Whether irrigation withdrawals will be significant or detrimental depends on amounts of streamflow available during drought periods and the frequency of such drought occurrences.

68-69:03F-017
VARIABLE ROW SPACING OF IRRIGATED COTTON AS A MEANS FOR REDUCING PRODUCTION COSTS AND CONSERVING WATER,
Longenecker, D. E., Thaxton, E. L., Jr., and Lyerly, P. J.
Texas Agricultural Experiment Station, El Paso
Agronomy Journal, Vol. 61, p 101-104, January-February 1969. 3 fig, 3 tab, 10 ref.

Descriptors: *Irrigation practices, *Water conservation, *Irrigation efficiency, *Cotton, Evaporation control, Crop yield.
Identifiers: *Variable row spacing, Skip row effect.

Results of three years' field studies of a new irrigation cotton row spacing pattern are reported. This new pattern, called Variable Row Spacing (V.R.S.), consisted of alternate wide (1.37 m) and narrow (0.66 m) rows with furrows only between the 0.66-m rows. Purpose of the new pattern was to conserve water and reduce production costs. Tests on both sloping and level irrigation systems are reported. The V.R.S. system was shown to be effective in maintaining yields while simultaneously presenting opportunity for reducing production costs through application of less water per irrigation, reductions in evaporation, more efficient utilization of applied water, more effective weed control, and earlier maturity of the crop. A partial skip-row effect was believed to be obtained without skipping any rows. Chief obstacle to adoption of the new system by growers has been inability of commercial spindle pickers to harvest the variable row spacing pattern.

68-69:03F-018
CONSUMPTIVE USE DERIVED FROM EVAPORATION PAN DATA,
Hargreaves, George H.
USAID, Bogota, Columbia.
American Society of Civil Engineers Proceedings, Journal of the Irrigation and Drainage Division, Vol. 94, No. IR1, Paper No. 5863, p 97-105, March 1968. 5 tab, 10 ref.

Descriptors: *Evapotranspiration, *Evaporation, *Consumptive use, *Climatic data, Irrigation programs, Rainfall, Evaporation pans.
Identifiers: Irrigation requirements, Evapotranspiration calculations.

Evapotranspiration measurements or computations provide basic information for the computation of irrigation requirements. Unfortunately, in underdeveloped or developing countries both evapotranspiration and weather data are usually of limited availability and for some proposed project areas nonexistent. Formulas and methods are required by engineers working on design and development of irrigation. These must permit the evaluation of needs and requirements for irrigation with an absolute minimum of data. Formulas are given for computing evaporation from climate data. Ratios of evapotranspiration to Class A pan evaporation are given for a large number of crops. Crops are grouped together or assigned general classifications whenever possible. Consumptive use coefficients converting evaporation to evapotranspiration are given by 10% increments of the crop growing season or vegetative cycle. A method of computing utilizable rainfall is presented and a formula is given for converting evapotranspiration to irrigation requirements. Irrigation requirements may be computed with several levels of data availability if temperature and rainfall measurements at the disposal of the engineer constitute the minimum of data required.

68-69:03F-019
SURFACE IRRIGATION HYDRAULICS-KINEMATICS,
Hart, William E., Bassett, Day L., and Strelkoff, Theodor
California University, Davis, Dept of Water Science and Engineering.
American Society of Civil Engineers Proceedings, Journal of the Irrigation and Drainage Division, Vol. 94, No. IR4, Paper No. 6284, p 419-440, December 1968. 8 fig, 18 ref, 3 append.

Descriptors: *Surface irrigation, *Infiltration, Storage, Hydraulics, Mathematical models, Mathematical studies, Unsteady flow, Non-uniform flow, Open channel flow, Recession curves.
Identifiers: Irrigation water advance, Irrigation water recession.

The mathematical solutions of surface irrigation flow and infiltration are reviewed. Their similarities lead to easy classification and simplification. An approach is proposed which uses defined shape factors to solve the advance of water, surface storage, storage depletion, recession, and infiltration during unsteady nonuniform flow over a porous bed. True solutions of the mass-conservation equation are analyzed and compared. Methods of numerically solving the equations are developed and discussed. Solutions are presented as dimensionless advance curves which can be used for field applications.

68-69:03F-020
SALT BALANCE, IRRIGATION EFFICIENCY, AND DRAINAGE DESIGN,
Bouwer, Herman.
Agricultural Research Service, Phoenix, Arizona.
Journal of the Irrigation and Drainage Division, ASCE, Vol. 95, No. IR1, Proc. Paper No. 6465, p 153-170, March 1969. 4 fig, 3 tab, 27 ref.

Descriptors: *Salt balance, *Salt tolerance, *Irrigation efficiency, *Leaching, *Drainage systems, Irrigation water, Root zone, Equations, Water utilization, Water requirements, Rates of application, Drains, Design, Salts, Crop response, Water table.
Identifiers: *Leaching efficiency, Salt concentration.

A simplified procedure was presented to predict how much irrigation water was necessary, in addition to that for evapotranspiration, to maintain salt balance in the root zone. The key factor in the procedure was the leaching efficiency, which appeared to range from 0.2 for fine textured soils to 0.6 for coarse textured soils. Also taken into account were salt tolerance of the crop, salt concentration of the irrigation water and evapotranspiration. The procedure accurately predicted known leaching requirements for salt balance of 3 irrigated regions. In defining irrigation efficiency, distinction was made between efficiency of water utilization and efficiency of water application. In conclusion, it was shown that drainage flow from the root zone decreased with time after an irrigation and that the water table response of a system of parallel drains to this flow could be computed for design of a drainage system to avoid high water tables.

68-69:03F-021
EFFECTS OF TILLAGE, NO TILLAGE, AND MULCH ON SOIL WATER AND PLANT GROWTH,
Jones, J. N., Jr., Moody, J. E., and Lillard, J. H.
Agricultural Research Service, Blacksburg, Virginia.
Agronomy Journal, Vol. 61, No. 5, p 719-721, September-October 1969. 2 fig, 3 tab, 7 ref.

Descriptors: *Soil-water-plant relationships, *Cultivation, *Mulching, Management, *Water conservation, Corn, Soil moisture.
Identifiers: *Zero tillage, *Killed sod planting, *Water use efficiency.

Seedbeds for corn (Zea mays L.) were prepared by both conventional tillage and the no-tillage method, each with and witnout surface mulches. The mulches consisted of killed grass sod on the no-tillage plots and straw applied on plots with conventional tillage. No-tillage plots without a mulch were obtained by removing the killed sod. Mulched treatments, whether of undisturbed killed sod on the no-tillage plots, or of straw on conventional plots, gave the lowest values for runoff and the highest values for soil water content and yield of corn. Soil water conserved by the mulches was reflected in an average grain yield increase of 1,932 kg/ha. Differences in total soil water among treatments were significant to a depth of 30 cm. The effect of tillage was minor, but the data indicate the value of the killed sod mulch in the no-tillage system.

68-69:03F-022

IRRIGATING WITH CUT-BACK FURROW STREAMS,

Sakkas, J. G., and Hart, W. E.
Thessaloniki University, Greece
Journal of the Irrigation and Drainage Division, ASCE, Vol. 94, No. IR1, p 91-96, March 1968. 2 tab, 3 ref.

Descriptors: *Drainage, *Irrigation,*Water distribution (Applied), Siphons, Furrow irrigation.

Nonuniformity of water distribution in irrigated fields results from unequal intake-opportunity times along the run. The cut-back of inflow (as suggested by previous workers) allows a large initial stream and was proposed to eliminate this inequality. This requires a variable number of furrows to be brought under irrigation at the beginning of successive time intervals. A mathematical analysis of the variation is presented and the results are summarized in tables which give the number of furrows started at the beginning of each time interval and being irrigated during each time interval. These tables enable the irrigator to distribute correctly the available quantity of water and, when using siphons, to estimate the number of siphons required

68-69:03F-023

THE INFLUENCE OF IRRIGATION, ROW SPACING, PLANT POPULATION, AND INOCULATION ON THE YIELD OF SOYBEANS IN CANTERBURY,

Dougherty, C. T.
Lincoln College, Canterbury, New Zealand, Plant Science Department.
New Zealand Journal of Agricultural Research, Vol. 12, p 367-380, 1969. 6 tab, 5 ref

Descriptors: *Irrigation, *Soybeans, *Plant populations, Agronomy, Cultivation, Soil-water-plant relationships.
Identifiers: Plant density, Inoculation.

A 2^5 factorial design was used to evaluate the influence of irrigation, row spacing, plant density, and inoculation on the growth and yield of Harosoy and Chippewa soybeans (Glycine max (L) Merrill) in Canterbury, New Zealand, in 1966-67. Higher yields were obtained from soybeans grown in 20 in. rows and at populations of 110,000 plants per acre than from those grown in 40 in. rows and at populations of 60,000 plants per acre. Irrigation and inoculation did not increase grain yields.

68-69:03F-024

SOIL WATER STORAGE DURING FALLOW IN THE CENTRAL GREAT PLAINS AS INFLUENCED BY TILLAGE AND HERBICIDE TREATMENTS,

Smika, D. E., and Wicks, G. A.
Nebraska Agricultural Experiment Station, North Platte, Nebraska
Soil Science Society America Proceedings, Vol. 32, No. 4, p 591-595, July-August, 1968, 6 tab, 12 ref.

Descriptors: *Mulching, *Tillage, Herbicide, Wheat moisture availability, Soil water.
Identifiers: Wheat-fallow rotations.

Soil water storage during the fallow period of winter wheat-sorghum-fallow (Triticum aestivum and Sorghum Vulgare) and alternate winter wheat-fallow rotations was measured during three fallow periods. Storage was greater when herbicides rather than conventional tillage practices were used as a result of treatments was distributed throughout the profile in the 3-year rotation, but the greatest increase occurred in the upper 60 cm of soil. In the 2-year rotation the nearly 14-cm increase in available water due to treatment was also present in the entire profile, but most of the storage increase occurred to a depth of 210 cm, with soil water content to a depth of 180 cm being at or near field capacity.

Soil water storage for the total fallow period of the 3-year rotation ranged from 18.6 to 22.3 cm, having corresponding storage efficiencies of 35.4 and 42.4%, for conventional tillage and complete herbicide treatments, respectively. Water storage for the complete fallow period of the 2-year rotation ranged from 18.6 cm with spring plowing (bare soil) to 23.8 cm with tillage stubble mulch to 32.5 cm with complete use of herbicides, and had storage efficiencies of 25.0, 32.0, and 43.7%, respectively.

68-69:03F-025
WATER CONSERVATION OVER WINTER IN THE NORTHERN PLAINS,
Willis, W. O., and Haas, H. J.
Agricultural Research Service, Mandan, North Dakota
Journal of Soil and Water Conservation, Vol. 24, No. 5, p 184-186, September - October, 1969. 5 fig, 24 ref.

Descriptors: *Precipitation, Soil moisture, Evaporation, Erosion, Runoff, Corn, Agriculture, Water conservation.
Identifiers: No-tillage system.

Data presented show that available soil moisture was always greater in the no-tillage system at planting. These differences, although they gradually decreased because of greater plant demands, continued throughout the growing season. The killed sod mulch insulated the soil and thereby suppressed evaporation, which is the primary mode of soil water loss for 1 to 1½ months after seedbed preparation. For the soils represented and the climatic conditions experienced during this study, the no-tillage system produced higher corn yields with less runoff, less evaporation, and negligible erosion. This resulted in more efficient use of water for crop production. In Virginia the no-tillage system appears to be exceedingly advantageous. Steeper slopes in good grass sods can be planted to corn without fear of erosion due to excessive runoff.

68-69:03F-026
ROOT DEVELOPMENT AND PHOSPHORUS UPTAKE BY TOMATO PLANTS UNDER CONTROLLED SOIL MOISTURE CONDITIONS,
Thorup, R. M.
Chevron Chemical Company, Fort Madison, Iowa.
Agronomy Journal, Vol. 61, No. 5, p 808-811, September-October, 1969.

Descriptors: *Root development, *Phosphorus, *Moisture availability, Tomatoes, Root systems, Soil-water-plant relationships.
Indentifiers: *Split-root techniques.

The effect of soil moisture tension upon root growth and phosphorus uptake by tomato plants was studied using a split-root technique. Root systems were developed in soil maintained at three different moisture levels--one well below PWP, another slightly below PWP, and a third within the "available" range. Root growth was very restricted at the lowest level of soil moisture--ataining a maximum length of 20 mm. At the level slightly below PWP, roots grew to a length of 90 mm, with substantial secondary root development. Maximum growth was attained at the moisture level maintained above PWP. At this level, roots reached a length of 150 mm and exhibited extensive secondary branching. Phosphorus uptake was measure by use of radioactive P. At all three moisture levels, phosphorus was taken up by the plants. A significant increase in uptake accompanied each increase in soil moisture. Moisture was transferred through the plant root system from zones of low tension to zones of high tension within the soil.

68-69:03F-027
TRICKLE IRRIGATION - A PROMISING SECOND TOOL FOR A BREAKTHROUGH IN FOOD PRODUCTION IN TROPICAL, SUBTROPICAL AND DESERT AREAS,
van't Woudt, B. D.
FAO Regional Office, Bangkok, Thailand.
International Commission on Irrigation and Drainage Bulletin, p 88-93, July 1968 -

January 1969. 2 fig, 1 tab, 8 ref, 1 append.

Descriptors: Irrigation, *Fertilization, *Irrigation practices, Irrigation efficiency, Soil-water-plant relationship, *Application equipment, *Saline water, *Irrigation systems, Crop response.
Identifiers: *Trickle irrigation, Drip irrigation.

A method, developed in Israel, is discussed, through which a water-fertilizer mix is continuously dripped on the soil at the base of a crop plant under field conditions. Early results, results from related work, and field observations show that this method may produce unexpectedly high yields, allow water of high salinity to be used, reduce drainage problems and permit complete automatization under field conditions in such a way that water and fertilizer applications completely cover but do not exceed plant needs. Cost of installation may vary from US$1,000 to $3,000 per hectare, but results may pay for this investment within a short time. Further development work and the need for a start with a moderate research program under south and east Asian conditions are discussed.

68-69:03F-028
SIMULATION OF WIND EFFECTS ON SPRINKLER PERFORMANCE,
Allison, S. V., and Hesse, V. L.
Litton International Development Corporation, Athens, Greece.
Journal of the Irrigation and Drainage Division, ASCE, Vol. 95, No. IR4, p 537-550, December 1969. 9 fig, 12 ref.

Descriptors: *Irrigation, *Irrigation efficiency, *Sprinkler irrigation, Computers, Model studies, Wind velocity, Wind pressure.

A brief review of the literature relating to wind effects on sprinkler performance is followed by presentation of a method by which system performance was simulated under winds varying in both speed and direction. This approach will permit the results of sprinkler tests performed anywhere in the world to be transferred to other locations for which adequate wind data exist. Relationships between uniformity and efficiency of irrigation are presented. The recommendation of sprinkler manufacturers and previous researchers, to the effect that the solution to the wind problem is simply to reduce spacings, is confirmed.

68-69:03F-029
PLASTIC PIPE AND WATER QUALITY,
Farish, C. A.
National Sanitation Foundation, Ann Arbor, Michigan.
Journal of American Water Works Association, Vol. 61, No. 9, p 480-482, September, 1969.

Descriptors: *Water quality, *Plastic pipes, Public health, Water pollution, Quality control.
Identifiers: *NSF Plastic standards.

There are several grades of plastics pipe available. Water works officials should insist upon such products meeting public health standards and sound engineering and physical standards before they use plastics for potable water. The plastics industry is growing rapidly and new materials are being developed and will continue to be developed. Old compounds are being modified to improve their properties. Compounds which are safe and suitable for hot water applications are becoming available; this could lead to a broader acceptance of plastics piping in general water distribution and expanded household applications. The role of the National Sanitation Foundation as an objective third party will be to continue its efforts in providing unbiased certification of those plastics which do not adversely affect water quality. The "NSF" seal signifies the product is nontoxic, will not adversely affect the taste, odor, or appearance of the standards to which it is produced and identified. Plastic pipe that has been proven through years of research and testing as public health safe for potable water use will not adversely affect water quality.

68-69:03F-030
IRRIGATION TIMING AND AMOUNTS,
Linacre, E. T., and Till, M. R.
Macquarie University, N.S.W., Australia, School of Earth Sciences.
The Journal of the Australian Institute of Agricultural Science, p 175-189, September 1969.

Descriptors: *Irrigation, Irrigation practices, Supplemental irrigation, *Evapotranspiration, Leaching, Plant growth, Plant physiology, Soil-water-plant relationships, Crop response, Infiltration, *Timing, *Water requirements, *Irrigation programs, *Tensiometers, *Atmometers, *Evaporation pans.
Identifiers: Sorption blocks, Australia.

This review deals with determining when irrigation is due, particularly by the use of soil-moisture tension meters or sorption blocks, or by water budgeting. Several approximations are given for determining soil moisture deficits to be used in a water budget. Crop evaporation estimates were made from measurements with an evaporimeter of atmometer, or from some formula such as Penman's. Brief accounts were given of advisory schemes, operated by central agencies in various parts of the world to aid the farmer in planning irrigation timing and amounts.

SECTION XIV

WATER QUANTITY MANAGEMENT AND CONTROL

CONTROL OF WATER ON THE SURFACE (Group 04A)

68-69:04A-001
DESIGN OF RECIRCULATING IRRIGATION SYSTEMS,
Bondurant, J. A.
Agricultural Research Service, Kimberly, Idaho.
American Society of Agricultural Engineers, Transactions, Vol 12, No. 2, p 195-198, 201, 1969. 6 fig, 3 ref.
(See 68-69:02E-002)

68-69:04A-002
A STUDY OF THE SPECIFIC YIELD IN LAND-DRAINAGE SITUATIONS,
Dos Santos, A. G., Jr., and Youngs, E. G.
Cambridge University (England), School of Agriculture.
Journal of Hydrology, Vol. 8, No. 1, p 59-81, May 1969. 11 fig, 24 ref.

Descriptors: *Specific yield, *Soil water, *Drainage, Gravitational water, Porosity, Permeability, Specific retention, Water storage, Percolation, Infiltration, Aquifers.
Identifiers: Soil air content.

From the definition of the specific yield in an unconfined aquifer, it is shown that the true specific yield is a function of the horizontal position and time and may be obtained from the measurements of localized fluxes and localized water-table movements. With the assumption of vertical flow above the water table, the specific yield is derived as the sum of the air content at the surface and the ratio of the rate of change of the volume of water held in the moisture profile above the water table to the rate of rise or fall of the water table. Since the latter ratio can be small in certain circumstances, the air content at the surface by itself is often a fair approximation to the specific yield. Results of measurements of all the specific yields, obtained in non-steady state drainage experiments using a completely permeable drain installation and a plastic drain installation in a hydraulic model sand tank, are presented. With the use of a virtual specific yield given by the air content at the surface in the midplane position between drain lines, calculated assuming steady state conditions with a stationary water table height and drain discharge for a given drain installation, rise and decay curves for the water table are calculated and compared with experiment, and fair agreement found.

68-69:04A-003
PREDICTING FIELD DISTRIBUTIONS OF SPRINKLER SYSTEMS,
Branscheid, Volker O., and Hart, William E.
California University, Davis, Dept of Water Science and Engineering.
American Society of Agricultural Engineers Transactions, Vol. 11, No. 6, p 801-803, 808, November-December 1968. 2 fig, 2 tab, 5 ref.

Descriptors: *Sprinkler irrigation, *Distribution patterns, *Forecasting, *Irrigation systems, *Water distribution (Applied), Distribution systems, Irrigation design, Irrigation efficiency, Spatial distribution, Laterals, Uniformity coefficient, Winds, Wind velocity.
Identifiers: Juxtapositioning.

Distribution of water over a field by sprinkler irrigation is an important aspect of system design and should therefore be known in advance. An approach was given for prediction of field distributions from single-sprinkler patterns. The theoretical method takes into consideration actual location of sprinklers in the field at the time of their operation. A single sprinkler and a lateral line of 13 equally spaced sprinklers were operated independently of one another at a test site. In order that their climatic conditions would be similar, both installations were run at the same time. The HSPA uniformity coefficient was used as a measure of uniformity. Lateral line sprinkler patterns, when combined, gave assumed field distribution. Single sprinkler data, when juxtaposed and overlapped, predicted field distribution as

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indicated by the uniformity coefficient. Results show that the juxtapositioning procedure is a valid one.

68-69:04A-004
SALT PENETRATION TECHNIQUE FOR SEEPAGE MEASUREMENT,
Bouwer, Herman, and Rice, R. C.
Agricultural Research Service, Phoenix, Arizona.
American Society of Civil Engineers Proceedings, Journal of the Irrigation and Drainage Division, Vol. 94, No. IR4, Paper No. 6304, p 481-492, December 1968. 7 fig, 2 tab, 2 ref.

Descriptors: *Seepage, *Infiltration, *Open channel flow, *Tracers, *On-site tests, Laboratory tests, Reservoirs, Canals, Irrigation.
Identifiers: Salt penetration, Seepage tracers.

Seepage rates in open channels or reservoirs are determined from the rate of salt penetration into the bottom material. A portion of the bottom is covered with crystals of a non-deflocculating salt. After dissolving, part of the salt enters the bottom with the seepage flow. The rate of advance of the peak of the resulting salt concentration 'wave' in the bottom material is measured with an electrical conductivity probe. Laboratory studies showed that the seepage rate could be calculated by multiplying this salt penetration rate by the porosity of bottom material. A field study in a reservoir showed excellent agreement between the seepage obtained in this manner and the rate of fall of the water surface. The salt-penetration technique is simple and it can be carried out under a wide variety of canal conditions.

68-69:04A-005
DISTRIBUTION OF PESTICIDES IN SURFACE WATERS,
King, P. H., Yeh, H. H., Warren, P. S., and Randall, C. W.
Virginia Polytechnic Institute, Blacksburg, Dept of Sanitary Engineering.
Journal of the American Water Works Association, Vol. 61, No. 9, p 483-486, September 1969. 7 fig, 2 tab, 7 ref.

Descriptors: *Pesticide kinetics, *Pesticide removal, *Adsorption, Soils, Coals, Distribution patterns, Activated carbon, Clays, Algae, Water purification, Water quality, Water chemistry.
Identifiers: Pesticide sorption.

Several papers on pesticide distribution in water, pesticide sorption in soil, and pesticide removal technology are reviewed and summarized, and experimental data are presented on pesticide sorption by soils, algae, and activated carbon. The pesticides studied are lindane and parathion. Experimental results are shown by sorption isotherms. In general, high-clay soils adsorbed about twice as much pesticide as sandy soils. Algae sorbed about 10 times as much as soils. Coal adsorbed about 2½ times as much as soil, and activated carbon adsorbed about 4 orders of magnitude more than soil.

68-69:04A-006
MECHANICAL STRUCTURES FOR FARM IRRIGATION,
Humpherys, Alan S.
Agricultural Research Service, Kimberly, Idaho.
American Society of Civil Engineers Proceedings, Journal of the Irrigation and Drainage Division, Vol. 95, No. IR4, p 463-479, December 1969. 17 fig, 2 tab, 3 ref, 3 append.

Descriptors: *Automation, *Irrigation systems, *Automatic control, *Control structures, *Hydraulic gates, Irrigation, Irrigation practices, Irrigation engineering, Turnouts, Mechanization, Water control, Movable dams, Water distribution (Applied), Timing, Farm equipment, Control systems, Check structures, Check dams, Furrow irrigation.

Mechanical, automatic irrigation structures that can save water and labor are being developed for surface irrigation systems. The timer-controlled and automatic water-pressure-controlled structures are being tested in various types of irrigation systems. A specially designed mechanical timer is used to control semiautomatic irrigation checks and gates. Generalized design information is presented for a timer-controlled check dam for lined and unlined ditches. A pressure gate that opens and closes automatically when water in the channel approaches a certain depth is described. Other structures include a drop gate, metal apron gate, and water level control checks. Certain operational problems such as rodent and weed control require greater emphasis with automatic irrigation than with conventional systems.

68-69:04A-007
A CLIMATOLOGICAL-TECHNOLOGICAL METHOD FOR ESTIMATING IRRIGATION WATER REQUIREMENTS FOR MAXIMUM CROP YIELDS,
Changnon, Stanley A., Jr.
Illinois State Water Survey, Urbana.
Journal of Soil and Water Conservation, Vol. 24, No. 1, p 12-15, January-February 1969. 4 tab, 13 ref.

Descriptors: *Irrigation efficiency, *Irrigation water, *Crop production, Crop response, Regression analysis, Forecasting, Irrigation practices, Supplemental irrigation, Illinois, Consumptive use, Evapotranspiration, Climates, Weather, Rainfall, Temperature.
Identifiers: Irrigation water requirements.

A method is given for estimating irrigation water requirements, using regression analysis of weather and crop production data including preseason precipitation, monthly mean temperatures, and monthly precipitation. The data used are from Illinois for the period 1930-1963. The results of analysis are tabulated for the 12 regional subdivisions of Illinois in terms of % increase of yield, weather types, July-August conditions, and frequency of yield increase for given amounts of irrigation water. The frequency information is accurate enough to use in planning irrigation water supplies anywhere historical climate and yield data are available.

68-69:04A-008
SOME ENVIRONMENTAL EFFECTS OF DRAINAGE IN FLORIDA,
Storch, William V., and Taylor, Robert L.
Central and Southern Florida Flood Control District, West Palm Beach.
American Society of Civil Engineers Proceedings, Journal of the Irrigation and Drainage Division, Vol. 95, No. IR1, Paper No. 6460, p 139-151, March 1969. 6 fig.

Descriptors: *Drainage, *Wetlands, *Florida, *Environmental effects, Citrus fruits, Economics, Estuaries, Flood control, Irrigation, Sedimentation, Water quality, Fish, Ecology, Plants, Social aspects, Conservation, Public rights.
Identifiers: Lake Okeechobee-Everglades Basin (Florida).

In 1959, intensive agricultural development started in a 780 sq mi region lying east of Lake Okeechobee in south Florida. In this 'wetland' region of flats, sloughs and ponds effective drainage to coastal waters has been the key to agricultural expansion By 1967 approximately 20% of the region was planted in citrus. Changes in the natural environment within the region took place almost immediately after drainage was initiated and indicates that the natural environment in adjacent areas can be affected as well. The effect of drainage on the immediate economic environment of the region has been favorable to date. However, natural environmental changes have produced tensions, with economic overtones, in the social environment resulting in conflict between agricultural and conservationist interests. Based on the experience gained in this region it is suggested that the proper function of public government is to evaluate the possible environmental effects of drainage programs and to use its financial, persuasive and regulatory powers to guide total environmental change in accordance with its estimate of the best public interest.

68-69:04A-009
A STUDY OF THE DRAINAGE OF IRRIGATED SAND DUNES USING AN ELECTRICAL RESISTANCE ANALOGUE,
Mein, R. G., and Turner, A. K.
Water Conservation and Irrigation Commission, N.S.W. (Australia).
Journal of Hydrology, Vol. 6, No. 1, p 1-14, January 1968. 9 fig, 13 ref.

Descriptors: *Resistance, *Analog models, *Dunes, *Electrical resistance, Irrigation effects, Drainage, Model studies.

Identifiers: *Artificial drainage, New South Wales, Impermeable layer.

The drainage of irrigated sand dunes by means of an electrical resistance analog is described. Sand dunes to be irrigated in New South Wales can be described as having an impermeable layer represented by either a horizontal plane at the base or a plane parallel to a sloping face. The artificial drainage of these dunes differs from situations covered by formulae commonly used for flat land. The electrical resistance analog is shown to be suitable for studying sand dune problems. The analog solutions are compared with the theoretical predictions of the appropriate formulae. Based on results obtained, recommendations are made on the best means of draining these sand dunes.

68-69:04A-010

FACTORS AFFECTING INFILTRATION AND RECHARGE IN A LOESS COVERED BASIN,

Williams, Roy E., and Allman, David W.
Idaho University, Moscow.
Journal of Hydrology, Vol. 8, No. 3, p 265-281, July 1969. 13 fig, 16 ref.

Descriptors: *Groundwater recharge, *Artificial recharge, *Infiltration, *Loess, *Percolation, Groundwater, Water table, Crops, Infiltrometers, Root systems, Hydrogeology, Piezometers, Aquifers, Idaho, Dyes, Tracers, Hydrographs, Soil erosion, Bibliographies.
Identifiers: Holes, Groundwater system.

Hydrographs of shallow piezometers installed in a basin overlain primarily by loess reveal that water infiltrating and percolating through the loess recharges groundwater. Local gravity groundwater flow systems adjacent to some intermittent streams thereby are established. Relief on the water table is at a maximum during late winter or spring, but decreases steadily through the summer when dry weather and maximal evapotranspiration minimize recharge. Cultivation practices and type of crop grown are 2 important factors that make the loess susceptible to infiltration and percolation. Smooth, heavily worked surfaces (commonly planted in winter wheat) act as a major limitation to infiltration capacity; soil moisture concomitantly is low beneath such surfaces. Root mats developed beneath grassy surfaces provide optimal conditions for infiltration and, consequently, for recharge. Measured infiltration capacities are often influenced by near-vertical tubular openings extending at least 30ft deep in the loess. Tracer studies indicate that when sufficient water is available and when surficial infiltration capacity is sufficiently high to form a zone of positive pressure above these openings, water is conducted ahead of the saturation front.

68-69:04A-011

ANALYTICAL AND COMPUTER SOLUTIONS OF TRANSIENT WATER TABLES FOR DRAINAGE OF SLOPING LAND,

Chauhan, H. S., Schwab, G. O., and Hamdy, M. Y.
Ohio Agricultural Research and Development Center, Columbus.
Water Resources Research, Vol. 4, No. 3, p 573-579, June 1968. 8 fig, 21 ref.

Descriptors: *Drainage, Analog computers, *Drawdown, Water management (Applied), *Drainage systems, Land management, *Porous media, Non-uniform flow, Mathematical studies, Laplaces equation, Stokes law, *Tile drains.
Identifiers: Boussinesq equation, Time-variable end conditions, Transient water tables.

Transient water table drawdown in sloping land lying between parallel, open ditches was obtained by solving Boussinesq's equation on the analog computer and by analytical methods for zero and time-variable end conditions at the ditches. Comparison of the results with observations made on a viscous flow model indicated that the solution with time-variable end conditions described the flow region better then the solution with zero end solutions.

68-69:04A-012
STOP WATERWEEDS WITH CHEMICALS,
Schachterle, D. M.
Bureau of Reclamation, Denver, Colorado.
Reclamation Era, Vol. 54, No. 4, p 108-109, November 1968. 3 fig.

Descriptors: *Aquatic weed control, Cattails, Pondweeds, *Irrigation canals, Ponds, Pondweeds, *Herbicides, *Aquatic plants, Irrigation operation and maintenance, Paints.
Identifiers: *Copper sulfate, *Xylene, *Dalapon, *Aquathol, Residue, *Watermilfoils, Reeds, Green algae.

Waterweeds are on the rampage throughout the West, particularly in irrigation canals and laterals. Increased use of herbicides to control weeds was limited due to the possible toxic effects on humans, warm blooded animals, fish, aquatic animals and plants, and its persistence level in soil and water. Aquatic plants were classified in three main categories: submersed, emersed and those that float or attach to surfaces. The aquatics reduce flows, cause increased siltation, and plug sprinkler irrigation and irrigation control devices. There were 20 herbicides registered for use with 11 being non-toxic to fish at the concentration used to control weeds. Costs of treatment were paid as operation and maintenance costs by the water user. Average cost for chemical control in Colorado was given.

68-69:04A-013
GEOMORPHIC GROUPING OF SOILS IN WATERSHED ENGINEERING,
England, C. B., and Holtan, H. N.
Hydrograph Laboratory, Beltsville, Maryland.
Journal of Hydrology, Vol. 7, No. 2, p 217-225, 1969. 3 figs, 2 tab, 20 ref.
(See 68-69:04D-001)

SECTION XV

WATER QUANTITY MANAGEMENT AND CONTROL

WATERSHED PROTECTION (Group 04D)

68-69:04D-001
GEOMORPHIC GROUPING OF SOILS IN WATERSHED ENGINEERING,
England, C. B., and Holtan, H. N.
Hydrograph Laboratory, Beltsville, Maryland.
Journal of Hydrology, Vol. 7, No. 2, p 217-225, 1969. 3 figs, 2 tab, 20 ref.

Descriptors: *Hydrology, *Watersheds, *Geomorphology, Soil classification, Infiltration, Rainfall, Runoff.

Soil properties significant to processes of infiltration, moisture storage, drainage, and the hydraulics of surface flow are related to topographic position. Areal and elevational distributions of soils provide a basis for interpretative grouping of soil mapping units in computations for watershed engineering. Soils on an ARS experimental watershed, grouped by deep upland, shallow hillside, and very deep depositional, were plotted on a contour map of the watershed surface. The elevational sequences thus obtained are representative of the hydraulic relationships between hydrologic response units in small agricultural watersheds. Profile characteristics, areal distribution, and relative elevation position of the units determine watershed response to storm rainfall.

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SECTION XVI

WATER QUALITY MANAGEMENT AND PROTECTION

IDENTIFICATION OF POLLUTANTS (Group 05A)

68-69:05A-001
EXTRACTION OF CATIONS FROM SILICATE MINERALS DURING THE DETERMINATION OF EXCHANGEABLE CATIONS IN SOILS,
Rhoades, J. D., and Krueger, D. B.
Agricultural Research Service, Riverside, California.
Soil Science Society of America Proceedings, Vol. 32, No. 4, p 488-492, July-August 1968. 1 fig, 7 tab, 21 ref.

Descriptors: *Soil analysis, Potassium, *Sodium, *Magnesium, Calcium, Alkaline earth metals, Arid lands.
Identifiers: *Soil minerals, Ammonium acetate extraction.

The extent to which silicate minerals release Ca, Mg, Na, and K during the determination of exchangeable cations in soils by the ammonium-acetate-extraction procedure was evaluated. The method of exchangeable-sodium evaluation used by the U.S. Salinity Laboratory was employed for this study with the exception that soil samples were replaced with reference mineral samples. Amounts of cations equivalent to 0.3,to 21.8 meq/100 g were extracted from the minerals by ammonium acetate. In general, the proportions of cations extracted decreased in the order Ca + Mg >>Na>K. Because of this phenomenon, complications are expected to occur in the evaluation of exchangeable Ca and Mg in arid-land soils, but not for exchangeable Na except under unusual circumstances. The latter circumstances are described and the general extent of error that may occur is estimated.

68-69:05A-002
A BATTERY POWERED PROPORTIONAL STREAM WATER SAMPLER,
Fredriksen, R. L.
Forest Service (USDA), Corvallis, Oregon, Pacific Northwest Forest and Range Experiment Station.
Water Resources Research, Vol. 5, No. 6, p 1410-1413, December 1969. 4 fig.

Descriptors: *Sampling, *Instrumentation, *Water quality, Water analysis, Data collections, Automation, Equipment.
Identifiers: Water samplers.

A stream water sampler was designed and tested to sample water from a stream at a rate proportional to the streamflow rate. A composite of samples taken in this manner is an estimate of the mean concentration of constituents carried by the stream while the sample was collected. The instrument is suitable for estimates of transport of suspended or dissolved constituents in small streams. The sampler can be built for under $1000.

68-69:05A-003
POLLUTION SURVEILLANCE BY NONCONTACT INFRARED TECHNIQUES,
Van Lopik, J. R., Rambie, G. S., and Pressman, A. E.
Texas Instruments, Inc., Dallas.
Journal of Water Pollution Control Federation, Vol. 40, No. 3, Part 1, p 425-438, March 1968. 14 fig, 10 ref.

Descriptors: *Remote sensing, *Path of pollutants, *Water pollution, *Monitoring, Surveys, Pollutant identification, Assessments, Instrumentation, Methodology, Texas.

Airborne infrared mapping techniques and their application to identification and monitoring of pollutants in streams and other bodies of water are described and illustrated. Thermal, organic and inorganic pollution can be determined and monitored, thus providing for rapid means to make on-the-ground measurements and, with aerial surveys, synoptic assessments of pollution parameters. Infrared mapping methods show the differences in infrared radiation flux over the area mapped. Sensing of temperature by this means can be used to map isotherms in water bodies and to trace

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thermal pollution, such as has been done in Galveston Bay. Proper selection of wavelengths allows identification of contaminants by their spectral emissivity characteristics.

68-69:05A-004
ECONOMIC ISSUES IN CONTROLLING AGRICULTURAL POLLUTION,
Taylor, G. C.
Economic Research Service, Washington, D.C.
Paper presented at the American Agricultural Economics Association Meetings, Lexington, Kentucky, August 19-20, 1969. 14 ref.

Descriptors: *Pollutants, *Agriculture, Decision making, Water pollution, Wastes, Sediments, Pesticides.

The objectives of this paper are to: (1) stress the multiple decision making aspects of controlling environmental pollution; (2) to highlight a number of significant economic issues involved; and (3) to suggest some significant areas where economic research can contribute to reduction of agriculturally related pollution. The agricultural pollutants considered were pesticides, animal wastes, sediment, plant nutrients, inorganic salts and minerals, forest and crop residues, agricultural processing wastes, and smoke, dusts, and other air pollutants. Sediment is the largest single pollutant of surface water. Decisions on environmental management are made at different points in time by millions of individuals and organizations, and it was proposed that to highlight a number of economic issues within a three-tier hierarchy of decision making levels, these levels were: first, the individual or firm; second, the bureaucratic and legal systems that operate to facilitate and constrain decisions at the first level; and topmost, the arenas of the legislature, the commissions, the high courts, and even the industry board rooms where broad decisions affecting the second level framework are made.

68-69:05A-005
DETERMINATION OF ORGANOCHLORINE INSECTICIDES IN SOILS AND WATERS,
Pionke, H. B., and Chesters, G.
Wisconsin University, Madison, Dept of Soils.
Soil Science Society of America Proceedings, Vol. 32, No. 6, p 749-759, November-December 1968. 82 ref.

Descriptors: *Analytical techniques, *Organochloride insecticides, *Application methods, Column chromatography, Thin-layer chromatography, Gas liquid chromatographic techniques.
Identifiers: *Soil, *Water, Methods of equilibrating.

Pertinent references on the determination of organochloride insecticides in soil and water samples are reviewed. The particular methods are chosen because of their applicability to heterogeneous systems which often provide problems due to coextraction of indigenous components. The review is divided into three principal sections, i.e., extraction of organochlorine insecticides from soils and waters, cleanup of soil and water extracts, and analysis of purified soils and water extracts. Criteria used in evaluating extraction procedures were based on methods of equilibrating the insecticide with the soil sample and the control of possible insecticide losses through degradation and volatilization. A large portion of the methods of final analysis of purified extracts is given over to gas-liquid chromatographic techniques. The gas-liquid chromatographic methods are discussed on the basis of peak resolution, detection and measurement of the insecticides, and confirmation of their identity. Thin-layer chromatographic, spectrophotometric, and other methods of determination of organochlorine insecticides in purified extracts are evaluated.

68-69:05A-006
MOVEMENT OF HERBICIDES IN RUNOFF WATER,
Sheets, T. J., and Lutz, J. F.
North Carolina State University, Raleigh, Pesticide Residue Research Laboratory.
Paper presented at the 1969 Winter Meeting, American Society of Agricultural Engineers, December 9-12, 1969, Chicago, Illinois. 8 p, 2 fig, 3 tab, 3 ref.

Descriptors: *Herbicides, 2,4-D, 2,4,5-T, *Pollutants, Path of pollutants, *Water pollution, Ground water, *Runoff, Weed control, Defoliants, Persistence, Environmental effects.

Identifiers: *Dicamba, *Picloram, Halewood clay loam.

Salts and esters of 4-amino-3,5,6-trichloropicolinic acid (picloram), 2,4,5-trichlorophenoxyacetic acid (2,4,5-T), and a few other phenoxy acids are widely used for control of perennial herbaceous weeds and woody plants throughout the United States. Also, these herbicides have been employed as defoliants in Southeast Asia. This project was initiated to study (a) movement of picloram, 2,4-dichlorophenoxyacetic (2,4-D), 2,4,5-T, and 3,6-dichloro-o-anisic acid (dicamba) in surface and ground water and (b) distribution and persistence of the herbicides in soil. This discussion was restricted to movement in water.

68-69:05A-007
CHROMATOGRAPHIC MODEL FOR PREDICTING PESTICIDE MIGRATION IN SOILS,
King, P. H., and McCarty, P. L.
Virginia Polytechnic Institute and Stanford University
Soil Science, Vol. 106, No. 4, p 248-261, 1968. 5 fig, 5 tab, 11 ref.

Descriptors: *Pesticides, Leaching, Soil water, Insecticides, Agronomy, Soil management.
Identifiers: Phosphorus insecticides, Pesticide movement.

The analysis of experimental data and its correlation with theoretical curves establishes the feasibility of predicting the extent to which organic phosphorus insecticides may be leached through soil columns. The method used for this prediction employs an equation describing chromations which would be expected in typical agricultural practice. The degradation of the pesticide molecule may normally be estimated from an equation describing first order decay kinetics. The combination of these two considerations is generally sufficient to develop a predicted elution curve for any pesticide through any soil assuming some available basis for estimating the distribution of the pesticide in soil-water environment and the decay reaction rate constant under the environmental conditions encountered. The major limitations of this method from the variability in distribution which occurs when the water solubility of the pesticide is approached, from the increased degradation of pesticide which occurs when biological acclimation takes place, and from the variability in theoretical plate height observed with differing soils and packing arrangements.

68-69:05A-008
AN ACID-FREE BATHOPHENANTHROLINE METHOD FOR MEASURING DISSOLVED FERROUS IRON IN LAKE WATERS,
McMahon, J. W.
Chalk River Nuclear Laboratories, Ontario, Canada.
Water Research, Vol. 3, No. 10 p 743-748, 1969, 2 tab, 10 ref.

Descriptors: *Iron, Bodies of Water, Filtration, Lake, *Acids.
Identifiers: *Acid-free bathophenanthroline method.

An acid-free solvent extraction technique, using bathophenanthroline, is proposed for measuring dissolved ferrous iron in filtered lake water. Ommission of HCl from the reagents eliminates the influence of acid and light on ferrous iron determinations. The effects of membrane filtration and ferric-bathophenanthroline interference on absorbance at 533 mμ are discussed.

68-69:05A-009
DISTRIBUTION OF CHLORINATED INSECTICIDES IN CULTIVATED SOIL,
Nash, R. G., and Woolson, E. A.
Agricultural Research Service, Beltsville, Maryland.
Soil Science Society of America Proceedings, Vol. 32, No. 4, p 525-527, July-August, 1968, 1 fig, 2 tab, 16 ref.

Descriptors: *Soil, *Insecticides, Aldrin, Dieldrin, Heptachlor, Pesticide residues, Cultivated lands.
Indentifiers: Chlorinated insecticides.

The 1966 distribution of nine chlorinated insecticides in a 38 cm profile was determined in a Congaree sandy loam soil which had received accumulations of 73 or 146 kg/ha as frequently repeated foliar applications during the 1951, 1952, and 1953 growing seasons. Residues of aldrin (pure and technical-determined as dieldrin because only trace amounts of aldrin were detected), dieldrin, isodrin + endrin, endrin, heptachlor + heptachlor epoxide, chlordane, BHC, toxaphene, and Dilan were found throughout the profile. BHC and isodrin were more uniformly distributed throughout the profile than aldrin, dieldrin, Dilan, Toxaphene, and chlordane. Between 85 and 90% of the latter insecticides were concentrated in the upper 23 cm, which probably corresponds to the cultivated layer. Residues were greatest in the 7.6 to 23 cm depths and least below the 23 cm depth. The relative mobility of the insecticides was BHC $\geq$ isodrin > heptachlor > endrin > toxaphene $\geq$ dieldrin $\geq$ aldrin $\geq$ Dilan $\geq$ chlordane.

SECTION XVII

WATER QUALITY MANAGEMENT AND PROTECTION

SOURCES OF POLLUTION (Group 05B)

68-69:05B-001
EXTRACTION OF CATIONS FROM SILICATE MINERALS DURING THE DETERMINATION OF EXCHANGEABLE CATIONS IN SOILS,
Rhoades, J. D., and Krueger, D. B.
Agricultural Research Service, Riverside, California.
Soil Science Society of America Proceedings, Vol. 32, No. 4, p 488-492, July-August 1968. 1 fig, 7 tab, 21 ref.
(See 68-69:05A-001)

68-69:05B-002
PREDICTING RETURN FLOWS FROM IRRIGATION,
Hurley, Patrick A.
Bureau of Reclamation, Denver, Colorado, Office of Atmospheric Water Resources.
American Society of Civil Engineers, Proceedings, Journal of the Irrigation and Drainage Division, Vol. 94, No. IR1, Paper No. 5838, p 41-48, March 1968. 3 fig, 3 tab, 3 ref.

Descriptors: *Return flow, *Irrigation, *Surface-groundwater relationships, Drainage effects, Drains, Deep percolation, Evapotranspiration.
Identifiers: Transient storage, Graphical solutions.

An analytical method for computing return flow or drainage from irrigation applications is presented and discussed. Computations consider aquifer properties, drain spacing, and deep percolation. A graph for determining the fractional part of percolation remaining in transient storage is included. By using the graph and simple digital procedures, realistic estimates of irrigation return flow can be determined. The method was used to determine monthly quantities for 13 yr of return flows in the Mesilla Valley, New Mexico-Texas.

68-69:05B-003
PLANT NUTRIENTS IN BASE FLOW OF STREAMS IN SOUTHWESTERN WISCONSIN,
Minshall, Neal, Nichols, M. Starr, and Witzel, S. A.
Wisconsin University, Madison.
Water Resources Research, Vol. 5, No. 3, p 706-713, June 1969. 1 fig, 1 tab, 9 ref.

Descriptors: *Water chemistry, *Solutes, *Nutrients, *Base flow, *Wisconsin, Nitrogen compounds, Phosphorus compounds, Potassium compounds, [illegible] Leaching, Weathering, Runoff.
Identifiers: Wisconsin River.

A 2-yr study was made of plant nutrients in the base flow of SW Wisconsin streams. The average base flow from 36 drainage areas covering a total of 643 sq mi was 4.9 in/yr. The annual nutrient losses in base flow were nitrogen, 1.1 lbs/acre; phosphorus, 0.10 lb/acre; and potassium, 1.8 lbs/acre. These losses were only 1/4 of those in the 1967 surface runoff from 0.01-acre plots at the Lancaster Experimental Farm and 3 Agricultural Research Service watersheds near Fennimore, Wisconsin. If precipitation of about 32 in. in a normal year contains 10 lbs N/acre, fertilizer applications 20 lbs N/acre, and subsurface or base flow an average of only 1 lb N/acre, then the other 29 lbs must be lost in surface runoff, retained for plant growth, or lost through denitrification. Total P lost per year, in the base flow, was 0.1 lb/acre, which is approximately 2% of the amount applied and only 1/10 of that lost in the 1967 spring surface runoff from the Lancaster plots and Fennimore watersheds. Soluble K lost per year in the base flow was about 2 lbs/acre, about 10% of that applied and only 1/4 of that lost in the 1967 spring surface runoff.

68-69:05B-004
AGRICULTURAL CHEMICALS AND OUR WATER RESOURCES,
Monke, E. J., and Goodrich, P. R.
Purdue University, Lafayette, Indiana, Department of Agricultural Engineering.
Paper Presented at 1968 Annual Meeting of American Society for Engineering Education, California University, Los Angeles, June 17-20, 1968. 17 p, 36 ref.

Descriptors: *Water pollution sources, *Water pollution effects, *Regulation, *Agricultural chemicals, *Reviews, Bibliographies, Pesticides, Fertilizers, Organic matter, Nutrients, Eutrophication, Nitrogen compounds, Legislation, Farm management, Land management.
Identifiers: Agricultural effects.

Literature pertaining to the effects of agricultural chemicals on water resources was reviewed. An attempt is made to put the contribution of chemicals from agricultural sources in proper perspective and to predict the effect of increasing regulation on the use and methods of application of agricultural chemicals. Proper management of agricultural chemicals from profit and safety motives alone would reduce the levels of unwanted chemicals reaching water supplies. Much greater research effort is needed in all phases of pollution reduction. In general, engineering education should be more concerned with the environment, its measurement and control.

68-69:05B-005
RURAL RUNOFF AS A FACTOR IN STREAM POLLUTION,
Weidner, R. B., Christianson, A. G., and Weibel, S. R.
Robert A. Taft Sanitary Engineering Center, Cincinnati, Ohio, Cincinnati Water Research Lab.
Journal of Water Pollution Control Federation, Vol. 41, No. 3, Part 1, p 377-384, March 1969. 6 fig, 10 tab, 3 ref.

Descriptors: *Water pollution sources, *Runoff, *Farms, *Farm wastes, Bacteria, Biochemical oxygen demand, *Erosion, Phosphates, Nitrogen compounds, Sediments.
Identifiers: Rural runoff.

Six cropped and mixed agricultural watersheds under experimental prevailing and improved crop land management at Coshocton, Ohio and an apple orchard over meadow at Ripley, Ohio, were instrumented to sample and gage rainfall and storm runoff from the fields. Under prevailing practices, monthly volume of runoff from fields was higher than that under improved practices such as contour plowing and strip cropping. More runoff developed from a field in corn than from one in wheat, and the least runoff developed from fields in meadow. Good correlations between rural runoff silt losses and total solids, and between total solids and BOD, COD, total hydrolyzable phosphate, and total nitrogen were found. Microbial tests showed that the bacterial sources were predominantly nonhuman, but total coliforms exceeded 1,000/100 ml in 90% of the samples in runoff from 2 of the rural watersheds.

68-69:05B-006
CONSERVING RESOURCES AND MAINTAINING A QUALITY ENVIRONMENT.
Wadleigh, Cecil H., and Britt, Clarence S.
Agricultural Research Service, Beltsville, Maryland.
Journal of Soil and Water Conservation, Vol. 24, No. 4, p 172-175, October 1969. 4 ref.

Descriptors: *Water resource development, *Water pollution, *Eutrophication, Government supports, Soil conservation, Industrial wastes, Municipal wastes, Fertilizers, Pesticides, Soil erosion, Animal wastes, Economics, Nitrogen, Water conservation.
Identifiers: *Soil runoff, Livestock.

Some of the problems involved in natural resource conservation are presented, with particular emphasis on the water pollution caused by agricultural runoff and livestock production. It is pointed out that the economics of the farming and livestock industry are often in conflict with the conservationists interests. It is suggested that the Dept of Agriculture adopt a cost-sharing program to encourage solutions to some of the problems. The article emphasizes the dangers of eutrophication induced by animal wastes. The author concludes with a statement of some of the accomplishments of the conservation movement in the area of soil and water resources.

68-69:05B-007

SOIL SALINITY IN THE WEST CENTRAL GEZIRA, REPUBLIC OF THE SUDAN,
Williams, M. A. J.
Australian National University, Canberra, Research School of Pacific Studies.
Soil Science, Vol. 105, No. 6, p 451-464, June 1968. 9 fig, 20 ref.

Descriptors: *Saline soils, *Soil surveys, Mapping, *Soil texture, Salinity, Rainfall, Permeability, Topography, Drainage, Chemical properties.
Identifiers: Africa.

Topsoil and subsoil salinity has been mapped for 1.3 m acres of land bordering the White Nile between Khartoum and Rabak. Salt reaches a peak in the second horizon except in the southern coluvial clays, where it increases with depth. The relations between salinity and rainfall, soil texture, topography, drainage, and certain soil chemical properties are discussed. In closed depressions and on the northern clay plains, topsoils are saline; on dunes, on certain recent alluvial terraces and on colluvial upland clays they are non-saline. Subsoil salinity is highest around former lake margins, and decreases with increasing elevation. Dominant salinity controls are soil texture, permeability, and topography, all of which are related to depositional history. In this area, rainfall and evaporation have a minor influence on salt distribution.

68-69:05B-008

WATER POLLUTION POTENTIAL ESTIMATED FROM FARM NUTRIENT BUDGETS,
Frink, C. R.
Connecticut Agricultural Experiment Station, New Haven.
Agronomy Journal, Vol. 61, No. 4, p 550-553, July-August 1969. 3 fig, 3 tab, 15 ref.

Descriptors: *Water pollution, *Nutrients, *Nitrogen, *Phosphorus, Potassium, Ground water, Eutrophication, Dairy industry, Fertilizers, Agronomy.

Estimates of the yield of nutrients to waterways from wooded and cultivated land vary considerably. Some of this variability can be attributed to the large variability in the N and P content of runoff water, to analytic uncertainties, and to the difficulties of obtaining accurate flow measurements. As an alternative assessment of agricultural eutrophication, nutrient budgets were derived for the highly specialized dairy farms in the Northeast. This analysis showed that under certain conditions these dairy farms could contribute significant amounts of nutrients, particularly nitrate, to groundwater. However, this loss of nutrients can be minimized by providing adequate cropland per cow, by selecting crops and animals that are efficient users of N, and by applying both manure and commercial fertilizers during the growing season.

68-69:05B-009

INFLUENCE OF SOIL MOISTURE TENSION ON NITRATE ACCUMULATION IN SOILS,
Sabey, B. R.
Illinois University, Urbana, Dept of Agronomy.
Soil Science Society of America Proceedings, Vol. 33, No. 1, p 263-266, January-February 1969. 6 fig, 1 tab, 12 ref.

Descriptors: *Soil moisture, *Moisture tension, Nitrates, Nitrification, Saturated soils.
Identifiers: *Soil moisture suction, *Ammonium oxidation.

The influence of soil moisture tension on NO_3^--N accumulation was studied in limed, silt loam, loessial derived soils to which a non-limiting source of NH_4^+-N was added. This was done by saturating the soils in an NH_4^+ solution, then subjecting the samples to 0, 0.1, 0.33, 1, 5, and 15 bars of soil moisture tension in conventional positive pressure equipment, and incubating the samples in a saturated atmosphere for varying intervals, to characterize the NO_3^--N accumulation curve with time. The maximum slope of the line gave an estimate of the K_M value or maximum rate of NO_3^--N accumulation in ppm/day. The K_M values in all soils were greatest at 0.1 bar tension with K_M values decreasing as soil moisture tension increased or decreased. The relative rates of NO_3^--N accumulation, R_M values or moisture rate indexes, varied much less than K_M values among soils. The mean R_M values at 0.1, 0.33, 1, 5, and 15 bars tension were 1.0, 0.71, 0.53, 0.29, and 0.13, respectively. The moisture rate index curve can be used to estimate the amount of NO_3^--N accumulation in soils similar to those used in this study at all soil moisture tensions between 0.1 and 15 bars if the rate of NO_3^--N accumulation is known at any one tension within the above range. The moisture rate index curve of this study and the temperature rate index curve of a previous paper are used in the previously proposed equation, $N-K_F R_K(t-t_F r_t)$ to estimate NO_3^--N accumulation in soils under varying conditions of temperature and soil moisture tension.

68-69:05B-010
APPLIED NITROGEN LOSSES IN RELATION TO OXYGEN STATUS OF SOILS,
Meek, B. D., Grass, L. B., and MacKenzie, A. J.
Southwestern Irrigation Field Station, Brawley, California.
Soil Science Society of America Proceedings, Vol. 23, No. 4, p 575-578, July-August 1969. 2 fig, 4 tab, 5 ref.

Descriptors: *Nitrates, Nitrogen cycle, *Denitrification, Irrigation, Anaerobic conditions, Ground water, Oxygen, Soil water.
Identifiers: *Soil redox potential.

The decrease in soil nitrate nitrogen as related to redox potential was studied in the laboratory and in the field in Imperial Valley, California. Partial anaerobic conditions were induced in laboratory flasks containing an atmosphere of 21% oxygen by adjusting the soil-water ratio. When the water content of a soil having a water saturation percentage of 48% was increased to 44.5% or above, large losses of N_2 gas occurred both with and without addition of organic matter. Significant denitrification coincided with a decrease in the redox potential (E_h). Measurement of redox potential and nitrate concentrations of ground water sampled at various depths in an irrigated field indicated that nitrate concentration was high near the surface but decreased at depths approaching the water table. The diminishing nitrate concentration and redox potential, with depth, indicate that some nitrates were reduced to nitrogen gas before they reached the water table. Only 1.5% of the 280 kg N/hectare applied to a cotton crop (Gossypium hirsutum L.) was discharged in the tile effluent during the growing season. Denitrification in the soil profile apparently reduced the amount of nitrate reaching the tile drainage system.

68-69:05B-011
AN INVESTIGATION OF THE POTENTIAL PROBLEM OF INCREASING BORON CONCENTRATIONS IN RIVERS AND WATERCOURSES,
Waggott, A.
Water Pollution Research Laboratory, Elder Way, Stevenage (England).
Water Research, Vol. 3, No. 10, p 749-765, October 1969. 4 fig, 11 tab, 40 ref.

Descriptors: *Water pollution sources, *Water pollution, *Boron, *Pollutant identification, Toxicity, Water pollution treatment, *Sewage treatment.
Identifiers: United Kingdom.

Sources of pollution by boron are considered a brief account of the chemical properties of borax and boric acid is given. The literature dealing with boron toxicity in relation to water pollution is summarized. Methods for determining boron in natural waters are discussed and experiments designed to test the application of one of them to sewage and sewage effluents are described. Results of determination of boron in surface waters, sewages, sewage effluents, and industrial effluents, are given and discussed. The insignificant removal of boron from sewage during normal treatment is demonstrated and other methods for reducing the boron content of waters are considered. It is concluded that the boron concentrations at present found in surface waters in the U.K. do not present an immediate toxicity problem.

68-69:05B-012
AGRICULTURE'S EFFECT ON NITRATE POLLUTION OF GROUNDWATER,
Stewart, B. A., Viets, F. G., and Hutchinson, G. L.
Agricultural Research Service, Fort Collins, Colorado.
Journal of Soil and Water Conservation, Vol. 23, No. 1, p 13-15, January-February 1968. 1 fig, 1 tab, 8 ref.
(See 68-69:02F-051)

68-69:05B-013

PHOSPHORUS FERTILIZATION OF HOPS,

Boawn, L. C., and Rasmussen, P. E.
Agricultural Research Service, Prosser, Washington.
Agronomy Journal, Vol. 61, No. 2, p 211-213, March-April 1969. 4 tab, 3 ref.

Descriptors: *Fertilization, *Phosphorus, Plant physiology, *Crop response.
Identifiers: *Hops, Humulus lupulus, P-induced zinc deficiency, Alpha acid, *Extractable soil P.

Hops were grown on field plots treated with five levels of phosphorus fertilization to determine the effect of P on vine growth, cone quality, and zinc nutrition. A maximum P treatment of 1,344 kg/ha, applied over a 5-year period, increased the extractable P level of the surface 20 cm of soil from 10 ppm to approximately 100 ppm. The P level in leaves and cones from this treatment was increased by approximately 0.10 to 0.15% P as compared with the no-P treatment. Increased levels of P had no observable effect on vine color and vigor or on total growth as determined by vine green weight. The critical level for P in sidearm leaves at early bloom was indicated to be below 0.25%. The alpha acid content of cones decreased where P fertilization exceeded approximately 500 kg/ha. However, this decrease was poorly correlated with the P content of leaves, indicating the lack of a direct causal relationship. The P treatments caused a definite reduction in the Zn concentration in leaf and cone tissues, but did not induce observable Zn deficiency symptoms.

68-69:05B-014

THE FATE OF NITRATES UNDER IRRIGATED AGRICULTURE,

Edwards, D. M., Fischbach, P. E., and Young, L. L.
Nebraska University, Lincoln, Dept of Agricultural Engineering.
American Society of Agricultural Engineers, 1969 Winter Meeting, December 9-12, 1969, Chicago, Illinois, Sherman House, Paper No. 69-751. 13 p, 6 fig, 14 ref.

Descriptors: *Nitrates, *Water pollution, *Irrigation, Irrigation practices, Water reuse, Saturate flow, Runoff, Fertilizers, *Water pollution sources, Furrow irrigation.

The movement of nitrates under irrigated field and laboratory conditions has been investigated. Nitrogen was applied to the soil by either mechanical chiseling or through the influent waters. First, a laboratory simulation of water movement in a furrow was made to determine if nitrates move from a band of fertilizer placed below the soil surface and to determine the magnitude of nitrate movement from the fertilizer through the soil profile when water is applied to the soil surface. The second phase of the study was a correlation between the laboratory study and actual field conditions. The third phase was a laboratory investigation to determine the downward rate of movement of nitrates into the soil profile. Once nitrates move below the soil surface they do not re-enter the runoff water except possibly through soil erosion and plant residuals left on the soil surface. Nitrates move essentially with the wetting front when the soil is initially air dry. Nitrates do not move at the same rate as the water when the soil is initially saturated. A runoff water re-use system is needed to prevent pollution of surface water due to runoff from an irrigated field when nitrogen fertilizer is injected into the influent water. With a properly designed and managed irrigation system, little or no movement of nitrates outside the root zone should occur.

68-69:05B-015

POLLUTANTS IN DRAINAGE RUNOFF,

Schwab, G. O., Taylor, G. S., and Waldron, A. C.
Ohio State University, Columbus, Dept of Agricultural Engineering.
American Society of Agricultural Engineers, 1969 Winter Meeting, December 9-12, 1969, Chicago, Illinois, Sherman House, Paper No. 69-710. 8 p, 4 tab, 15 ref.

Descriptors: *Drainage water, Surface runoff, Drainage, Path of pollutants, *Pollutants, *Water pollution, Pollution abatement, Fertilizers, *Pesticides, Phosphorus, Nitrogen, 24-D, Heptachlor, *Sediment.
Identifiers: Atrazine, Dicamba.

Drainage water from tile and surface drains in a heavy-textured soil in northern Ohio was analyzed for sediment, plant nutrients, and several pesticides over a 3-year period. In 1967 and 1968 drainage water samples were collected from two 3-inch irrigations each year, but not from rainfall. In 1969 samples were obtained for the 7-month growing season, during which one 3-inch irrigation was applied and a 11.6-inch flood occurred. The tiled plots were level and surrounded with a dike to prevent surface runoff. Corn was grown each year. Half of the plots received conventional tillage and the other half were not tilled. In all plots, weeds were controlled by chemicals. The average sediment and nutrient losses from each of the five 3-inch irrigations were generally low. From the first irrigations following pesticide application, atrazine losses averaged 10.7% of the amount applied for the tile. Losses of 2, 4D in 1967 were only about 0.1% of the amount applied. Dicamba losses for the 1969 growing season varied from 27 to 37% of the amount applied. Loss of heptachlor for the 1969 season was insignificant. For the 1969 growing season, sediment in the drainage water from the conventional tillage plots contained five times or more sediment than from the no-tillage plots.

68-69:05B-016
MOVEMENT OF HERBICIDES IN RUNOFF WATER,
Sheets, T. J., and Lutz, J. F.
North Carolina State University, Raleigh, Pesticide Residue Research Laboratory.
Paper presented at the 1969 Winter Meeting, American Society of Agricultural Engineers, December 9-12, 1969, Chicago, Illinois. 8 p, 2 fig, 3 tab, 3 ref.
(See 68-69:05A-006)

68-69:05B-017
EFFECTS OF SOIL AND CROP MANAGEMENT PRACTICES ON THE REMOVAL OF STRONTIUM-90 BY PLANT UPTAKE, LEACHING, RUNOFF AND EROSION,
Haghiri, F.
Ohio Agricultural Research and Development Center, Wooster, Ohio.
Agronomy Journal, Vol. 61, No. 5, p 793-796, September-October, 1969. 2 fig, 7 tab, 11 ref.

Descriptors: *Planting management, *Erosion, *Leaching, *Runoff, Strontium, Radioisotopes, *Rotations, Plant growth substances.
Identifiers: Leachate.

Long-term field investigations are being conducted to study the effect of management practices on the removal of ^{90}Sr by runoff, leaching, erosion and plant uptake. The management practices consist of one crop rotation with high and low rates of lime, permanent grass, continuous corn, and gravel mulch with no vegetation. Over a 5-year period, the ^{90}Sr content of the soil in a 0-10-cm depth decreased in all cropping systems. The percent ^{90}Sr loss by runoff water and sediment was negatively correlated with time while the percent ^{90}Sr in the leachate water increased with time. The percent ^{90}Sr removal by runoff and leachate water has maximum under gravel mulch and minimum under grass treatments. Sod crops were more effective in minimizing the ^{90}Sr loss in runoff and leachate water than cultivated crops. High Ca accumulating crops such as alfalfa removed more ^{90}Sr than low accumulators such as corn. High rates of lime reduced the ^{90}Sr uptake by crops and the removal by leachate water.

68-69:05B-018
NUTRIENTS IN AGRICULTURAL TILE DRAINAGE,
Pierce, W. H., Beck, L. A., and Glandon, L. R., Jr.
Federal Water Pollution Control Administration, Alameda, California.
1969 Winter Meeting American Society of Agricultural Engineers, December 9-12, 1969, Chicago, Illinois, Sherman House, Paper No. 69-709. 29 p, 9 fig, 6 tab, 17 ref.

Descriptors: *Nitrates, Drains, *Drainage water, *Tile drainage, Water quality, *Water pollution sources, Path of pollutants, Soil water, *Fertilizers, Phosphorus, Denitrification, Soil moisture, Nitrogen, Soils.
Identifiers: *San Joaquin Valley.

A number of tile drainage systems were selected for monitoring within each heavily tiled area. Larger systems with a large number of rather closely spaced laterals on as many different soils as available were selected. Only tile drainage systems underlying fields having active irrigation and fertilization program were selected. Wide variations were observed in tile drainage discharge and nutrient concentrations between the various systems monitored for any given time of year. Field investigations were initiated to develop estimates of the amount of nitrogen contributed by fertilizers and residual soil nitrogen to tile drainage nitrogen yields. Four tile fields were selected, and at each field soils, soil moisture at tile depth, soil moisture at depths of 10, 15, 20 and 25 ft, and tile drainage were sampled and analyzed for nitrates, chlorides and conductivity. Field studies of soils were conducted to characterize soil stratigraphy, and determine field moisture, nitrate-nitrogen and specific conductivity in order to locate the lateral and up-slope limits of the high-nitrate bearing soils. Denitrification losses from several soils, under saturated conditions, were studied by means of laboratory scale lysimeters.

68-69:05B-019
FIXATION OF ATMOSPHERIC NITROGEN BY NON LEGUMES IN WET MOUNTAIN MEADOWS,
Porter, L. K., and Grable, A. R.
Agricultural Research Service, Fort Collins, Colorado.
Agronomy Journal, Vol. 61, No. 3, p 521-523, May-June 1969. 1 fig, 5 tab, 8 ref.
(See 68-69:02K-020)

68-69:05B-020
POLLUTION OF WATER FROM AGRICULTURAL SOURCES,
Harrold, Lloyd L.
Agricultural Research Service, Beltsville, Md.
The Ohio Engineer, Vol. 29, No. 4, p 10, April 1969. 3 ref.

Descriptors: *Water pollution, *Agricultural chemicals, *Fertilizer, *Animal waste, *Water pollution surces, Leaching, Streamflow, Erosion.
Identifiers: *Farm chemicals, *Food production, Automatic sampler.

USA became the world's foremost food quality and quantity producer by use of farm fertilizer and other chemicals. Phosphate fertilizer and dieldrin pesticide attach to soil and do not dissolve readily in runoff water. They become a significant part of the pollution of water bodies only as soil is eroded by runoff water. Nitrate fertilizer pollutes surface and subsurface water bodies where excessive amounts are applied and under high rates of rain and irrigation. It is water soluble. Beef cattle feedlots of over 70,000 head in one unit raised the nitrate content of the soil 20 feet deep to a maximum of 5,000 pounds per acre. Research is defining the involvement of agriculture in the pollution problem by determining the fate of agri-chemicals applied on farm lands and the effects of animal wastes. It is also developing cropping systems and other means for stabilizing pollutants from agricultural operations.

68-69:05B-021
AGRICULTURAL POLLUTION OF WATER BODIES,
Edwards, William M., and Harrold, Lloyd L.
Agricultural Research Service, Washington, D.C.
The Ohio Journal of Science, Vol. 70, No. 1, p 50-56, January 1970.

Descriptors: *Water pollution,*Farms, *Livestock, *Phosphorus, *Nitrates, *Pesticides, *Soil conservation, Runoff, Erosion, Percolation, Sediment, Waste.
Identifiers: Lake Erie, Barnyard, Solids, Liquids.

Pollution of Ohio's water bodies is of growing public concern; industrial, urban, and rural sources are becoming the subject of critical examination. Rural sources are soil sediment, plant nutrients, animal waste, and pesticides. Pesticides and phosphorus are absorbed rapidly and strongly to soil particles. Therefore, reductions in sediment, phosphorus, and pesticide pollution are achieved by soil-erosion-control farming practices. More acres need to be brought under erosion-control practices. Nitrates dissolve in water and are carried by surface flow to streams and lakes, and by percolating water to underground aquifers. Increases in the use of nitrogen fertilizer, in evidence almost everywhere, could result in serious contamination of water bodies, if soil enrichment greatly exceeds the crop demand. Areas where large-scale livestock and poultry production is concentrated are also potential sources of serious pollution. In Ohio, animal-waste pollution problems are being studied at The Ohio State University, and movement of pollutants in surface and subsurface waters on drainage plots near Castalia are being studied by the Ohio Agricultural Research and Development Center and on agricultural watersheds by USDA Agricultural Research Service at Coshocton, Ohio.

68-69:05B-022
AGRICULTURE'S CONTRIBUTION TO THE FERTILIZATION OF CANAL LAKE,
Campbell, F. R., and Webber, L. R.
Guelph University (Ontario), Dept of Soil Science.
Journal of Soil and Water Conservation, Vol. 24, No. 4, p 139-141, August 1969. 2 fig, 2 tab, 9 ref.

Descriptors: *Eutrophication, *Nutrients, *Water pollution sources, *Agriculture, Nitrogen, Phosphorus, Fertilizers, Runoff, Farm wastes, Productivity, Aquatic plants.
Identifiers: Canal Lake, Ontario.

Water quality, weed growth, and nutrient loadings of Canal Lake, Ontario were studied between May and November 1968. Relatively little nitrogen and phosphorus are contributed by the area's low-level agriculture. Precipitation contributes more nitrogen than streams. Agriculture contributes about 0.15 lb/acre, about a twentieth of the yield from an equivalent nonfertilized area. Most nitrogen probably comes from lake sediments, plants, and fixation of nitrogen in the lake. About 84% of the phosphorus probably originates in a lake upstream of Canal Lake. The agricultural yield is only about 63 lb from 30,000 acres. These contributions of nutrients are negligible considering the total nutrients in the lake, the nutrient load of the streams, and other sources of nutrients.

68-69:05B-023
MOVEMENT OF DDT AND NITRATES DURING GROUND-WATER RECHARGE,
Scalf, Marion R., Dunlap, William J., McMillion, Leslie G., and Keeley, Jack W.
Robert S. Kerr Water Research Center, Ada, Oklahoma.
Water Resources Research, Vol. 5, No. 5, p 1041-1051, October 1969. 10 fig, 1 tab, 19 ref.

Descriptors: *Path of pollutants, *Groundwater movement, *DDT, *Nitrates, *Tracking techniques, Tracers, Water wells, Pumping, Recharge, Discharge (Water), Adsorption, Dispersion.
Identifiers: Aquifer tests, Pumping tests, Ogallala aquifer.

The Robert S. Kerr Water Research Center, U.S. Department of the Interior, and Southwestern Great Plains Research Center, U.S. Department of Agriculture, recently cooperated in a field investigation of the fate of DDT and nitrates when artificially recharged into the Ogallala aquifer. The USDA provided recharge and observation wells and hydraulic equipment for injecting 350 gpm of water with known concentrations of radioactive tracer, DDT, and nitrates. Following 10 days of recharge, the recharge well was pumped for 12 days at 500 gpm. During recharge the nitrates moved to the observation wells essentially at the same rate as the recharge water, and the DDT was absorbed to the aquifer material very near the recharge well. During the pumping phase, 94% of both the recharge water and the nitrates was recovered. The concentration of DDT in the pumped water was about 16 times the recharged concentration at initiation of pumping but dropped below recharge concentration within one hour. Apparently, a major portion of the DDT introduced during recharge was not recovered during pumping but remained in the aquifer.

68-69:05B-024
PRELIMINARY FIELD STUDIES USING EARTH RESISTIVITY MEASUREMENTS FOR DELINEATING ZONES OF CONTAMINATED GROUND WATER,
Warner, D. L.
Federal Water Pollution Control Administration, Ohio Basin Region.
Groundwater, Vol. 7, No. 1, p 9-16, January-February 1969. 7 fig, 10 ref.

Descriptors: *Ground water, Water quality, *Water pollution, *Resistivity.
Identifiers: Long Island, Texas.

The measure of earth resistivity is a possible means of detecting and outlining zones of ground water contamination where a resistivity contrast exists between contaminated and uncontaminated ground water. As a preliminary evaluation of the use of electrical resistivity for defining zones of contaminated ground water, five sites on Long Island and three sites in western Texas were examined. The surveys at three of the Long Island sites and at one of the western Texas sites were at least partially successful in their objectives. The lack of success at the other sites is attributed to the particular physical conditions that existed. Further effort to develop electrical resistivity for evaluating ground water quality variations is encouraged.

68-69:05B-025
DISTRIBUTION OF CHLORINATED INSECTICIDES IN CULTIVATED SOIL,
Nash, R. G., and Woolson, E. A.
Agricultural Research Service, Beltsville, Maryland
Soil Science Society of America Proceedings, Vol. 32, No. 4, p 525-527, July-August 1968, 1 fig, 2 tab, 16 ref.
(See 68-69:05A-009)

68-69:05B-026
FATE OF DDT AND NITRATE IN GROUNDWATER,
Scalf, M.R., Hauser, V.L., McMillion, L.G., Dunlap, W.J., and Keeley, J.W.
Robert S. Kerr Water Research Center, Ada, Oklahoma.
U.S. Department of the Interior, April, 1968. 46 p, 29 fig, 3 tab, 33 ref.

Descriptors: *Groundwater, Aquifers, Water storage, Water wells, Recharge, *Nitrates, Fertilizers, Water pollution sources, Water pollution, Water quality, *DDT, Insecticides, Organic pesticides, Pesticides, *Groundwater recharge, Waste water (pollution).
Identifiers: Ogallala Aquifer.

The Ogallala Aquifer was recharged at 348 gpm for a period of 10 days with water taken from an irrigation well 2,280 feet from the recharge point. Tritiated water, nitrate, and p,p'-DDT were injected into the recharge stream at concentrations of 210μμc/ml, 24.46 mg/l, and 74 ppb, respectively. The system was monitored by chemical analyses of samples taken at several observation wells with principal interest in those located at 33, 66, and 150 ft from the injection well. Water levels were monitored continuously at 16 points located up to 1,000 ft from the recharge well. Tritiated water (H_3O) can be used satisfactorily in groundwater studies to define the movement of water and at the same time the three most important points resulting from this study were: 1) When present, nitrate pollution of the Ogallala is probably of more immediate concern than DDT because of its ability to move through the aquifer; 2) A well, used for domestic purposes, should not be recharged with water in which DDT is suspected becaused of the possible release of DDT contaminated aquifer materical into water subsequently pumped from the well; 3) Considerable caution must be used in extending this work to other pesticides because of the myriad of solubilities and the obviously varied adsorption characteristics encountered.

68-69:05B-027
COLLECTED PAPERS REGARDING NITRATES IN AGRICULTURAL WASTE WATERS,
Federal Water Quality Administration, San Francisco, California, Series 13030ELY 12/69
U.S. Department of the Interior, December, 1969. 186 p, 55 fig, 37 tab, 66 ref.

Descriptors: *Water pollution sources, *Return flow, *Nitrates, *Water pollution control, *California, Drainage engineering, Drainage effects, Irrigation programs, Irrigation systems, Water management (Applied), Eutrophication, Path of pollutants, Groundwater, Irrigation effects, Drainage water, Water quality, Excess water (Soils), Return flow, Drainage programs.
Identifiers: *San Luis Drain (Calif), *San Joaquin Master Drain (Calif), *Central Valley (Calif).

This is a collection of 11 papers dealing with the closely related topics of (a) concentrations of nitrates occurring in subsurface agricultural waste waters, (b) the source of nitrates, and (c) possible methods for controlling or removing them. The work all deals with subsurface agricultural waste waters of the San Joaquin Valley in California, but much of the information may have general application.

68-69:05B-028
CHARACTERISTICS AND POLLUTION PROBLEMS OF IRRIGATION RETURN FLOW,
Utah State University Foundation, Logan
U.S. Department of the Interior, 1968, Research Report No. 13. 43 p, 49 fig, 2 tab, 11 ref.

Descriptors: *Irrigation practices, *Return flow, *Salinity, *Water pollution sources, *Water quality control, Consumptive use, Water Pollution effects, Water reuse, Water rights, Pesticide residue, Irrigation water.
Identifiers: *Irrigation return flow, Research needs.

An extensive review of the literature was made to assess the present state of scientific knowledge and technology regarding water pollution problems associated with the practice of irrigation and occurring in irrigation return flow. Literature dealing specifically with irrigation return flow was scarce. Eighty percent of the irrigated area of the U.S. was found to fall within an area in which the water demands exceed or will exceed the supply by 1980. Water quality changes during irrigation were found to be influenced by: (1) biochemical action, (2) erosion, (3) evaporation and transpiration, (4) filtration, (5) heat transfer, (6) ion exchange, (7) leaching, (8) precipitation, and (9) sorption and chelation. The effect of irrigation on the subsequent reuse of water by other users was considered. Feasibility studies have been conducted on treating and disposing of return water. A need was found for economic research explicitly concerned with irrigation return flow. The legal aspects of reuse and water quality of irrigation return flows were examined and the recommendation made for more intensive study of the inseparable nature of quality-quantity management in relation to institutional, economic, and legal restrictions. This article contains 245 references and a separate bibliography of 700 entries.

SECTION XVIII

WATER QUALITY MANAGEMENT AND PROTECTION

EFFECTS OF POLLUTION (Group 05C)

68-69:05C-001
AGRICULTURE'S EFFECT ON NITRATE POLLUTION OF GROUNDWATER,
Stewart, B. A., Viets, F. G., Jr., and Hutchinson, G. L.
Agricultural Research Service, Fort Collins, Colorado.
Journal of Soil and Water Conservation, Vol. 23, No. 1, p 13-15, January-February 1968. 1 fig, 1 tab, 8 ref.

Descriptors: Groundwater, Pollutants, Nitrates, Fertilizers, Leaching, Water pollution sources, Nitrites, Water quality, Solid wastes, Agriculture, Alfalfa.
Identifiers: Nitrogen balance, Methemoglobinemia, South Platte River, Feedlots, Colorado.

Because of the danger of nitrates to humans and livestock and the stimulating effect of nitrogen on the production of aquatic weeds, agriculture's use and production of nitrogen forms are receiving much attention. Increased uses of nitrogen fertilizers and commercial and farm feedlot operations have prompted questions concerning their contributions to groundwater pollution. Fertilizers, feedlots and domestic sewage effluent were believed to be the "new" sources of nitrate and nitrites in groundwater. Analysis of 129 core samples reaching from the soil surface to the water table or bedrock within the South Platte River Valley in Colorado are given. Research needs regarding the effects of nitrogen fertilizers and feedlots on groundwater are enumerated.

68-69:05C-002
ON THE ECOLOGICAL CLASSIFICATION OF INLAND SALINE WATERS,
Ziemann, H.
Wasserwirtschaftsdirektion Werra-Gera-Unstrut, Erfurt, D.D.R.
Water Research, Vol. 2, No. 6, p 449-567, 1968. 2 fig, 2 tab, 25 ref.

Descriptors: *Saline water, Ecology, Aquatic habitats, *Ecosystems, Ecotypes, *Biological communities, Halophytes, *Classification, Biology, Salts, *Diatoms.
Identifiers: *Halobic index, *Alkalichloride, Poikilohalinity.

To find a biological basis for the classification of inland saline water, a quantitative relationship between biological associations of diatom communities and salinity in several inland saline waters were examined. The sampling points in the rivers Werra and Wipper were situated at stations where the water had different salt contents. Sampling for chemical examination took place daily, at several stations weekly; the collection of biological samples was done once in every season. The reaction of the diatom communities is not dependent on the quantity of the salt content but on the physiological effect of the salinity which may be modified by the combination of ions present. Consequently, by an examination of the biological associations, the waters may be ecologically characterized, independent of any knowledge of the hydrographical factor. On the basis of the biological effects of the salt content, a classification of the inland saline waters of the alkalichloride type is proposed, in which the classes are determined by the halobic index.

68-69:05C-003
RELATION OF AGRICULTURE TO GROUNDWATER POLLUTION: A REVIEW,
Robbins, J. W. D., and Kriz, G. J.
North Carolina State University, Raleigh, Dept of Biological and Agricultural Engineering.
Transactions of the American Society of Agricultural Engineers, Vol. 12, No. 3, p 397-403, May-June 1969. 2 tab, 97 ref.

Descriptors: *Agricultural engineering, *Groundwater, *Pollutants, *Farm wastes, Agriculture, Pollution abatement, Farm management, Waste water (Pollution), Pesticides, Insecticides, Herbicides, Bibliographies, Saline water, Irrigation water, Waste water disposal, Waste disposal, Water pollution, Water pollution control, Water pollution sources.

Identifiers: Groundwater quality, Pollution control.

Groundwater is a water resource and a potential medium for receiving wastes. Agricultural enterprises produce wastes that can lead to rapid degradation of groundwater. Agricultural engineers are responsible for evaluating agricultural groundwater pollution problems and recommending control and abatement measures. The purpose of this paper is to orient agricultural engineers on groundwater pollution problems caused by agricultural practices in three general areas: (1) evaluation of groundwater as a receiving medium for agricultural wastes; (2) characterization of the source of the pollutants; and (3) delineation of the types of solutions needed for agricultural groundwater quality problems. Agricultural groundwater pollutants reviewed are animal wastes, fertilizers, pesticides, plant residues, and saline waste water.

68-69:05C-004
EFFECT OF FATTY ALCOHOL ON CHANGE IN SOIL WATER DURING THE SUMMER FALLOW PERIOD,
Brengle, K. G., and Mann, H. O.
Colorado State University, Fort Collins, Department of Agronomy.
Journal of Soil and Water Conservation, Vol. 24, No. 1, p 25, 26, January-February 1969. 1 tab, 6 ref.

Descriptors: *Octadecanol, Fallowing, *Soil water, *Summer, *Evaporation control, Alcohols, Colorado, Semiarid climates, Retardants, Rates of application, Precipitation (Atmospheric), Water loss, Water storage, Soil surfaces, Evaporation pans, Cultivation.
Identifiers: *Powder.

A study was conducted to determine whether fatty alcohols would improve efficiency of soil water storage during the fallow period under semiarid conditions in southeastern Colorado. Octadecanol in powder form was applied at rates of 0, 300, 600, and 900 pounds per acre in a randomized block experiment with five replications. No significant differences in soil water changes were noted in any of the three years during which the test was conducted, but there was a trend for less water loss with 900 pounds of fatty alcohol per acre. Surface application of fatty alcohol at the rates used in this study did not retard soil water loss enough to warrant its use in a fallow system.

68-69:05C-005
IMPACT OF AGRICULTURAL POLLUTANTS ON WATER USERS,
Law, J. P., Jr., and Bernard, H.
Robert S. Kerr Water Research Center, Ada, Oklahoma.
Transactions of the American Society of Agricultural Engineers, Vol. 13, No. 4, p 474-478, July-August 1970. 3 tab, 23 ref.

Descriptors: *Water pollution sources, *Farm wastes, *Herbicides, *Water supply, Recreation, *Agricultural chemicals, *Fertilizers, *Nitrates, *Phosphates, Saline water, Water quality, Water pollution, Pesticides, Fishkill, Water sports, Wildlife.

The major sources of agriculturally associated water pollution activities include animal wastes, irrigation return flows, fertilizers, and biocides. The problems resulting from these sources involve high BOD loadings, bacteria, and nutrient compounds of nitrogen and phosphorus from animal wastes, increased salinity concentrations from irrigation return flows, algae stimulating phosphorus and nitrogen in fertilizers, and the lengthy residuals of chlorinated hydrocarbons and herbicides common in many biocides. Many of the agricultural pollutants are eventually found in public water supplies and cannot be economically removed with present technology. Many western rivers contain both salinity and nitrate nitrogen at levels above standards established for potable water supplies, and others such as sulfates, chlorides, and certain biocides are also found in high concentrations. Aquatic life, fish, and higher forms of wildlife are either being threatened by oxygen depletions associated with overenrichment of algae mass or increased pesticide concentrations resulting from accumulations in the food chain. Aesthetic and recreational use is impaired when agricultural pollutants include bacteria above limits of public safety or contribute to excessive algal growth. Agricultural use if often restricted by bacteria and salinity in irrigation water.

68-69:05C-006
ADSORPTION OF PHOSPHORUS BY LAKE SEDIMENT,
Harter, R.D.
Connecticut Agricultural Experiment Station, New Haven.
Soil Science Society of America, Proceedings, Vol. 32, No. 4, p 514-518, July-August 1968. 5 fig, 1 tab, 12 ref.

Descriptors: *Phosphorus, *Eutrophication, *Algae, Sodium compounds, *Sediments.

The sediment of an eutrophic lake is capable of adsorbing a large amount of phosphorus from the water. To study the sorption mechanism, between 0 and 2.2 mg P was added to 0.1-g sediment samples (1:50 sediment-solution ratio). After equilibrium had been established, P remaining in solution was determined, and adsorbed P was extracted with 0.5N NH_4F and 0.1N NaOH. Whereas all P adsorbed into the NaOH- extractable fraction appeared to occur as an iron phosphate, NH_4F apparently extracted P bonded by two different mechanisms. When less than about 0.1 mg P was added, NH_4F extracted a tightly bonded form of P, probably occurring as an aluminum phosphate. When more than 0.1 mg P was added, additional P in a more loosely bonded form was adsorbed into the NH_4F-extractable fraction. The loosely bonded P appeared to be independent of Al content of the sediment, and could be removed by successive water extraction. The capability of the sediment to adsorb considerable loosely bonded P means that large influxes of P into the lake may be held temporarily and subsequently released to growing plants and algae.

SECTION XIX

WATER QUALITY MANAGEMENT AND PROTECTION
WASTE TREATMENT PROCESSES (Group 05D)

68-69:05D-001
IRRIGATION WITH RECLAIMED WASTE WATER,
Hirsch, L.
Hirsch and Koptionak, Civil and Sanitary Engineers, San Diego, California.
Water and Waste Engineering, Vol. 6, No. 4, p 58-60, April 1969. 1 fig, 2 tab, 4 ref.

Descriptors: *Irrigation water, *Water utilization, *Water reuse, *Irrigation practices, Reclamation, Waste water, Water demand, *Reclaimed water.
Identifiers: San Diego, California.

Reclaimed water will be a major element of total water management in the future. Reclaimed wastewater involves the same general management problems as the use of potable water for irrigation; namely, the interrelationship of water, soil, and plants. These relationships were considered in view of the sanitary, aesthetic, economic and other practical factors governing the use of and reuse of water. This article reviews the various important aspects of the use of reclaimed wastewater for irrigation purposes.

68-69:05D-002
METHOD OF REMOVING NITRATES FROM WATER,
St. Amant, P. P., and Beck, L. A.
Robert S. Kerr Water Research Center, Ada, Oklahoma.
Agricultural and Food Chemistry, Vol. 18, No. 5, p 785-788, September-October 1970.
1 tab, 7 ref.

Descriptors: *Nitrates, *Denitrification, *Algae, Ponds, Drainage, Bacteria, Leaching, Water quality, Tertiary treatment.
Identifiers: *Algae stripping, San Francisco Bay System, San Joaquin Valley.

A 1967 Federal Water Pollution Control Administration report indicated that serious pollution problems would result if the tile drainage wastewater from the San Joaquin Valley were discharged without treatment into the San Francisco Bay System. The report further indicates that nitrogen in the nitrate form is the most serious potential pollutant. Nitrogen removal in ponds and filters by bacterial denitrification and algae stripping was evaluated. Algae stripping tests were run in two ponds of varying depths and it was found that detention time in growth ponds was approximately 4 to 5 days during summer months and 15 days in winter months. The ponds were evaluated by covering one with floating styrofoam and one uncovered. A 90% nitrate-nitrogen removal was achieved in the covered pond with 10 day retention time. Filter denitrification studies were performed in columns with a 6-ft media depth. The major variables studied were filter media and detention time which varied from ½ to 2 hrs. Media size ranged from sand to 3-inch diameter gravels. Greater than 90% removal of the 20 mg/l of nitrate-nitrogen was achieved at all detention times studied. Land requirements for methods vary from 9000 acres to 150 acres and costs are roughly $25 to $30 per million gallons for each of the methods.

68-69:05D-003
WATER REUSE: A TEXAS NECESSITY,
Fleming, R. D., and Jobes, H. D.
Texas Water Quality Board, Austin.
Journal of the Water Pollution Control Federation, Vol. 41, No. 9, p 1564-1569,
September 1969. 2 fig, 1 tab.

Descriptors: *Water reuse, *Water demand, *Texas, Irrigation water treatment, Economics, Water allocation (Policy), Water management (Applied).
Identifiers: Texas Water Plan.

By the year 2020, Texas' estimated 33.5 million people will need 12 mil acre-ft of water for municipal and industrial uses, and over 16 mil acre-ft for irrigation. Because the annual safe yield of ground and surface water is only 20 mil acre-ft,

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development of other water sources is a necessity. To plan for the future need, several processes (desalinization, weather modifications, and water importation) are being investigated. To develop the importation idea, the Texas Water Plan was initiated in 1964. This paper describes the main aspects of the plan (water reuse, tapping the Mississippi River, control of irrigation) to help meet Texas' future needs.

68-69:05D-004
CHEMICAL INTERACTIONS OF WASTEWATER IN A SOIL ENVIRONMENT,
Hajek, B. F.
Battelle-Northwest, Richland, Washington.
Journal of Water Pollution Control Federation, Vol. 41, No. 10, p 1775-1786, October 1969. 9 fig, 20 ref.

Descriptors: *Soil disposal fields, *Water chemistry, *Wastewater (Pollution), Water reuse, Biodegradation, Permeability, Soil chemical properties, Soil physical properties, Filtration, Clays, Groundwater movement.
Identifiers: Soil-wastewater relationships.

The performance of soil as a wastewater disposal and water reclamation resource often can be predicted from laboratory data which characterize wastewater, soil, and soil-wastewater relationships. Many parameters must be studied to assess fully the ability of soil to assimilate wastewater. Some of the significant wastewater parameters are: pH, pollutant form and concentration, concentration of accompanying ions, temperature, and volume disposal characteristics. Significant soil parameters are: bulk density, grain size distribution, mineral composition, exchange capacity, and resident exchangeable cations. Soil-wastewater relationships are characterized by batch equilibrium and dynamic soil column studies. Either theoretical or empirical approaches often can be applied to these data and used to predict pollutant migration rates and concentration distributions.

68-69:05D-005
RATIONALE OF STANDARDS FOR USE OF RECLAIMED WATER,
Foster, Herbert B., Jr., and Jopling, William F.
California State Dept. of Public Health, Berkeley.
American Society of Civil Engineers Proceedings, Journal of Sanitary Engineering Division, Vol. 95, No. SA3, Paper No. 6609, p 503-514, June 1969. 1 append.

Descriptors: *Water reuse, *Reclaimed water, *Standards, *Water quality, *California, Waste water treatment, Tertiary treatment, Sewage treatment, Legislation, Regulation.
Identifiers: Reclaimed water standards (Calif.).

California has established standards for reclaimed wastewater used for crop and landscape irrigation and recreational impoundments. Insofar as possible, the standards avoid the use of specific quality parameters in order to minimize monitoring requirements which would be burdensome to small operations. The major exception is that, where a disinfected reclaimed wastewater is necessary, daily coliform bacteria analyses are required. This requirement was one of 4 major controversial points which are presented. Other major points raised in the development of standards are specification of operational controls and practices in the production and use of reclaimed wastewater, and quality requirements for the various uses.

68-69:05D-006
CANNERY WASTE TREATMENT BY SPRAY IRRIGATION-RUNOFF,
Bendixen, T. W., Hill, R. D., DuByne, F. T., and Robeck, G. G.
Robert A. Taft Sanitary Engineering Center, Cincinnati, Ohio, Cincinnati Water Research Lab.
Journal of the Water Pollution Control Federation, Vol. 41, No. 3, Part 1, p 385-391, March 1969. 2 fig, 9 tab, 4 ref.

Descriptors: *Canneries, *Industrial wastes, *Foods, *Tomatoes, Irrigation, Runoff, Soil treatment, Grasslands, Wastewater treatment, Ohio, Chemical oxygen demand.
Identifiers: *Cannery waste, *Spray irrigation, Food processing.

A spray irrigation-runoff system is used to treat the wastes from a tomato-processing plant. The facility employs 5 plots containing a total of 165 acres. The waste is sprayed intermittently, 6 hrs on and 6 hrs off, at the top of 5% grassy slopes and runoff collected after runs of 100 to 200 ft. Tests show that 30 to 40% of waste runs off, with the treatment efficiencies as follows: COD, 95%; nitrogen, 93%; phosphates, 84% and suspended solids, 97%. Rainfall increases the runoff and decreases the efficiencies.

68-69:05D-007
SEWAGE NUTRIENT REMOVAL BY A SHALLOW ALGAL STREAM,
Hemens, J., and Mason, M. H.
National Institute for Water Research of the South African Council for Scientific and Industrial Research, Pretoria, South Africa.
Water Research, Vol. 2, No. 4, p 277-287, 1968. 5 fig, 1 tab, 28 ref.

Descriptors: *Algae, *Nitrogen, *Phosphorus, *Sewage effluent.
Identifiers: *Sewage nutrient removal.

The use of algae ponds for removing nitrogen and phosphorus by assimilation from secondary sewage effluent suffers from the disadvantage of inefficient light utilization by the dense algal cultures required and from the practical problem of economically removing the algae from suspension. An experiment is described in which the pH increase resulting from algal photosynthesis in a shallow stream was used to remove phosphate by precipitation and nitrogen by assimilation and loss to the atmosphere as ammonia gas. Association of precipitated phosphate with the algal cells produced a granular algal sediment easily removed by gravity settlement. Removal of nitrogen and phosphate exceeded 90 percent in the warmer seasons, but at winter temperatures the efficiency was less, due to decrease in the elevation of pH value. The method appears to have possible application for rural communities in equable climates where water reuse is desirable.

68-69:05D-008
SELF-PURIFICATION IN AN OPEN DITCH,
Brink, Nils.
Uppsala University (Sweden), Inst. of Limnology.
Water Research, Vol. 2, p 481-503, 1968. 19 fig, 5 tab, 19 ref.

Descriptors: *Open channels, *Self-purification, *Sewage, Flocculation, Organic matter, Pollution, Abatement, Sedimentation, Waste water treatment.

The self-purification of running water after pollution by sewage was studied in a ditch with a small water depth. Both during winter (0-1 deg C) and summer, a high degree of self-purification with respect to organic matter, nutrient salts, and bacteria was observed within a distance of 200-300 meters and during a time less than 4.5 hour. Flocculation and sedimentation of organic and inorganic substances were the predominant processes, especially in winter, but also ordinary breakdown and building-up of organic matter and nitrification took place. At high flow in spring and autumn, deposited bottom sludge was carried away by the stream. Such an oxidation ditch, without disturbing drainage water from the surroundings during high flow, is well suited as an alternative method of treating sewage. A drop of up to about 90% in organic matter, nitrogen, and phosphorus over a distance of less than 300 meters was observed in winter and summer. The same was the case with coliform and general heterotrophic bacteria to near 100%. In spring and autumn, no such decreases occurred. An oxygen sag was found during winter and summer. A balance between oxygen and BOD5 was reached after 350 m. In spring and autumn, no sag was found.

68-69:05D-009
TREATMENT OF HIGH NITRATE WATERS,
St. Amant, Percy P., and McCarty, Perry L.
Federal Water Pollution Control Administration, Fresno, California.
American Water Works Association 89th Annual Conference, May 21, 1969, San Diego, Calif. 18 p, 2 fig, 3 tab, 5 ref.

Descriptors: *Waste water treatment, *Denitrification, *Anaerobic conditions, Aerobic conditions, Anaerobic bacteria, Filtration, Porous media, Aeration.

Identifiers: Anaerobic filtration treatment.

Biological denitrification was investigated as an economically feasible way to remove nitrates from waters to control discharge of nutrients into bodies of water. Pilot-plant studies conducted to estimate chemical requirements, to evaluate anaerobic filter media, and to determine the operating parameters of the anaerobic filtration process. Biological denitrification in anaerobic filters is a reliable process for removing excess nitrates from water supplies. An organic electron donor must be added to accomplish denitrification, and methanol has been found to be a satisfactory and inexpensive material for this purpose. Use of one-inch gravel filter media and a detention time of one hour is sufficient for 90% or greater removal of approximately 20 mg/l of nitrate-nitrogen in water with temperature of 12 deg C and above. Costs, operating characteristics, and filter design data are tabulated.

68-69:05D-010
DESALINATION OF IRRIGATION RETURN WATERS,
Sword, B.R.
Federal Water Pollution Control Administration, Fresno, California, San Joaquin Project.
Water Pollution Control Research Series, 13030 ELY, p 80-105, December, 1969. 14 fig, 7 tab, 1 ref.

Descriptors: *Irrigation, *Return flow, Saline water, Desalination, Desalination processes, Impaired water quality, *Electrodialysis, Osmosis, *Reverse osmosis, Demineralization.
Identifiers: San Joaquin Valley, Total dissolved solids.

Experiments were conducted using drain tile waters from a 400-acre field which had percolated through 5 to 9 feet of soil and contained a total dissolved solids (TDS) concentration of from 2,500 to 3,000 mg/l. The units tested were an Aerojet-General Reverse Osmosis Water Purifier and an Ionics Electrodialysis Demineralizer. The initial reverse osmosis stack was able to achieve over 90 percent TDS removal; however, nitrate and boron removals averaged less than 27 percent. The second stack removed 85 percent of the TDS with negligible nitrate and boron removals. The electrodialysis unit had an average TDS removal of 23 percent, with a maximum of 36 percent. The cost for supplies and power for reverse osmosis (Stack II) was $0.41 per thousand gallons of product. The same costs for electrodialysis came to $0.15 per thousand gallons of product, with a comparable cost to reverse osmosis for a product of 500 mg/l TDS. It is concluded that desalination of San Joaquin Valley tile drainage water is technically feasible.

SECTION XX

WATER QUALITY MANAGEMENT AND PROTECTION
ULTIMATE DISPOSAL OF WASTES (Group 05E)

68-69:05E-001
THE ANAEROBIC FILTER FOR THE DENITRIFICATION OF AGRICULTURAL SUBSURFACE DRAINAGE,
Tamblyn, T. A., and Sword, B. R.
Federal Water Pollution Control Administration, Fresno, California.
Proceedings of the 24th Industrail Waste Conference, May 6,7, and 8, 1969, Purdue University, Lafayette, Indiana, p 1135-1150. 6 fig, 6 tab, 19 ref.

Descriptors: *Denitrification, *Subsurface drainage, *Nitrate removal, Chemical analysis.
Identifiers: *Anaerobic filter, San Joaquin Valley.

This paper discusses one of the many investigations concerned with the "safe" disposal of the up to 580,000 acre-feet ($7.2x10^8$cu m) per year of saline water (subsurface drainage). Two basic techniques of nitrate removal are being investigated in two types of vessels: deep ponds and anaerobic filters. The operation of upflow anaerobic filters for efficient removal of nitrate-nitrogen from the subsurface agricultural drainage of the San Joaquin Valley by anaerobic denitrification is discussed. Filters of three sizes (4, 8, and 36 inch diameter) were operated under field conditions with hydraulic detention times varying from 0.5 hr. to 6 hr. Various media were investigated, ranging from fine activated carbon to one-inch diameter aggregate. The required concentration of influent biodegradable organic carbon was also investigated.

68-69:05E-002
DEGRADATION OF WASTEWATER ORGANICS IN SOIL,
Thomas, R. E., and Bendixen, T. W.
Robert A. Taft Sanitary Engineering Center, Cincinnati, Ohio.
Journal of the Water Pollution Control Federation, Vol. 41, No. 5, p 808-813, May 1969. 3 tab, 17 ref.

Descriptors: Land disposal, Sewage treatment, Sludge, Soil fertility, Soil microbiology, Soils.

Land disposal of wastewater sludge has become economically competitive with other disposal methods and also can be beneficial to the land. Soil microorganisms were found to be able to digest much of the organic carbon contained in primary and secondary wastewater effluents according to a series of lysimeter studies. Large variations in temperature, the loading rate, and the duration of dosing had no effect on the percentage of the organic carbon which was degraded. A silica sand and a sandy loam soil were dosed with a septic tank effluent and effluent from a high-rate trickling filter. Sludge loadings equivalent to 30/tons/yr/acre (68 metric tons/yr/ha) of organic carbon can be applied to sandy soils for extended periods with no detrimental accumulation of organic residues. This would equal 100 tons/yr/acre (225 metric tons/yr/ha) of dried digested sludge solids.

68-69:05E-003
DIGESTED SLUDGE DISPOSAL ON CROP LAND,
Hinesly, Thomas B., and Sosewitz, Ben.
Illinois University, Urbana, Dept of Agronomy.
Journal of the Water Pollution Control Federation, Vol. 41, No. 5, p 822-830, May 19 1969. 3 fig, 4 tab, 2 append.

Descriptors: *Sludge disposal, *Crops, *Agriculture, *Irrigation, *Fertilizers, Stabilization, Digestion, Sludge, Sludge digestion, Nutrients, Trace elements, Odors, Infiltration.
Identifiers: Chicago (Illinois).

After an exhausted study to determine the best solids disposal solution, the Metropolitan Sanitary District of Greater Chicago concluded that digestion followed by land disposal could cope with Chicago's 1000 tons/day of sludge successfully at a cost of

$20-$23/ton. Research designed to determine groundwater contamination, the effect of heavy metals and crop irrigation parameters, was conducted. At the Northeast Agronomy Research Center, digested sludge was applied by furrow irrigation at weekly intervalson crop land planted with corn and kenaf. The rates were 1, 0.5, 0.25, and 0 inches for a total of 6 weeks. Average corn yield was 111.9, 114.2, 96.2, and 66.3 bushels per acre, respectively. While all the results are not in for the first years research and demonstration projects on the 8 acre and 30 acre test plots, some observations can be summarized. (1) The crops responded favorably to digested sludge. (2) Offensive odors have not been a problem. (3) Flies were never a problem. (4) Furrow irrigation is preferred to sprinkler irrigation. (5) Application of nitrogen in amounts greater than those needed for crop production will increase nitrate level in drainage water.

68-69:05E-004
HYDROGEOLOGIC CONSIDERATIONS IN LIQUID WASTE DISPOSAL,
Born, S. M., and Stephenson, D. A.
Wisconsin University, Madison, Dept of Geology.
Journal of Soil and Water Conservation, Vol. 24, No. 2, p 52-55, March-April 1969.
2 fig, 7 ref.

Descriptors: *Waste water disposal, *Irrigation, *Sprinkler irrigation, Hydrogeology, Soils, Porosity, Permeability, Groundwater movement, Soil water movement, Infiltration, Percolation, Adsorption, Filtration.
Identifiers: Spray disposal.

The geohydrology of liquid waste disposal by irrigation is reviewed. Knowledge of geologic conditions is necessary for spray irrigation disposal of wastes. The thickness, nature, and distribution of unconsolidated surface deposits determine infiltration, adsorption storage, and downward movement of waste water. Infiltrometer tests may be used in situ, or laboratory examination of samples can yield quicker, less accurate information. The condition of bedrock determines rate of water movement and effectiveness of filtration. Flow systems must be studied to learn where wastes will travel.

68-69:05E-005
A STUDY OF WASTEWATER IRRIGATION THROUGH COMPUTER SIMULATION,
Cypra, K. J., Cowlishaw, W., and Bauer, W. J.
Bauer Engineering, Inc., Chicago, Illinois.
Water Resources Bulletin, Vol. 6, No. 6, p 935-943, November-December 1970. 2 tab, 4 fig, 3 ref.

Descriptors: Model studies, *Wastewater treatment, Wastewater irrigation, *Water quality, *Computer simulation, Planning, Lagoons.
Identifiers: *Muskegon, Michigan, *Metropolitan water resources management.

Wastewater irrigation is a re-emerging method for dealing with an area's wastewater, particularly in Northern temperate climates in the U.S. Muskegon, Michigan, typical of a medium-sized northern urban area, is currently adopting wastewater irrigation to meet its present and future wastewater treatment needs. Design of a system for Muskegon, Michigan must consider, among other things, the quantity of storage needed prior to irrigation and the quality of water in the storage lagoons. A computer simulated operation of the storage and irrigation aspects of the proposed wastewater irrigation system resulted in a better understanding of storage requirements and critical quality parameters (particularly anaerobic conditions during spring break-up). Further refinements of the model are expected to be of value in subsequent phases of final system design.

SECTION XXI

WATER QUALITY MANAGEMENT AND PROTECTION

WATER TREATMENT AND QUALITY ALTERATION (Group 05F)

68-69:05F-001
TREATMENT OF HIGH NITRATE WATERS,
St. Amant, Percy P., and McCarty, Perry L.
Federal Water Pollution Control Administration, Fresno, California.
American Water Works Association, 89th Annual Conference, May 21, 1969, San Diego, Calif. 18 p, 2 fig, 3 tab, 5 ref.
(See 68-69:05D-009)

68-69:05F-002
BIOLOGICAL DENITRIFICATION OF WASTEWATERS BY ADDITION OF ORGANIC MATERIALS,
McCarty, P. L., Beck, L., and St. Amant, P.
Stanford University, Stanford, California, Dept of Civil Engineering.
Proceedings of the 24th Industrial Waste Conference, May 6,7,8, 1969, Purdue University, Lafayette, Indiana, p 1271-1285. 2 fig, 17 ref.

Descriptors: *Denitrification, *Organic material, Removal, *Eutrophication, *Methanol, *Acetic acid, *Ethanol, *Acetone, *Sugar.

Biological denitrification has been frequently suggested as a method for the removal of nitrate nitrogen from wastewaters when required for the control of eutrophication in receiving waters. This study was instigated by the California Department of Water Resources to evaluate the effectiveness, required concentration, and cost of several possible organic materials for denitrification. Agricultural wastewater collected from subsurface irrigation drains near the Agricultural Wastewater Treatment Center, Firebaugh, California, was used for the studies. The five commercial organic compounds evaluated for denitrification were methanol, acetic acid, ethanol, acetone, and sugar. Initial studies were conducted with batch feed followed by periodic analysis. The most promising chemical at the completion of the batch experiment was selected for evaluation in a semi-continuous treatment study. Methanol was selected as the most desirable organic chemical of the five studied for denitrification.

68-69:05F-003
REMOVAL OF NEMATODES BY RAPID SAND FILTRATION
Wei, I.W., Engelbrecht, R.S., and Austin, J.G.
Illinois University, Urbana, Department of Civil Engineering
Journal of the Sanitary Engineering Division, ASCE, Vol. 95, No. SA1, p 1-16, February, 1969, 10 fig, 4 tab, 12 ref.

Descriptors: *Filtrations, *Water pollution, *Worms, Sands, *Nematodes, Sanitary engineering, Filters.
Identifiers: Rapid Sand Filters.

The results of a study on rapid sand filtration indicated that, with a low percent nematode mobility, the removal of nematodes increased with decrease in sand size. As the percent mobility increased, the removal of nematodes decreased. Also, as the percent mobility increased, the percent removal of nematodes by all sand sizes studied approached one another. An evaluation of mobile nematodes in the influent and effluent showed that most mobile nematodes could eventually pass through the sand bed even though some of them could be temporarily retained in the sand during the early stages of the filtration process. From a balance of nematodes entering and leaving the system, it also appeared that mobile nematodes could dislodge the nematodes which were initially retained in the sand bed. Thus, these two phenomena resulted in an overall decrease in removal of nematodes. The effect of increased mobility, which tended to decrease nematode removal, was more significant than the expected benefits of using chemical pretreatment.

68-69:05F-004
NEMATODE REMOVAL BY RAPID SAND FILTRATION,
Seth, A.K., George, M.G., Bewtra, J.K., and Sharma, V.P.
Central Public Health Engineering Research Institute, Chandrawal Water Works II, Delhi, India.
Journal of the American Water Works Association, Vol. 60, No. 8, p 962-968, August 1968. 14 fig, 2 tab, 8 ref.

Descriptors: *Filtration, Water purification, Filters, Sands, *Water treatment, Chlorination, Turbidity, Public health, Potable water, Nematodes, Soil microbiology.
Identifiers: *Rapid sand filter, India.

Since normal doses of chlorine put into water supplies have no effect on nematodes, a study was made to obtain the correlation between concentrations of nematodes in filter influent and effluent while using different sizes of filter media at different loading rates. A pilot plant with 4 filters containing sand with effective sizes of 9.45, 0.55, 0.65, 0.75 mm and uniformity coefficient of 1.35 was used in the study. Filter runs were 24 hours in length with head losses and turbidity checks being made every six hours. Composite 6-hour samples from clarified water and filtrates were tested for turbidity, worm population and temperature. The conclusions were: 1) removal of nematodes by rapid sand filtration is independent of the effective size of the filter media between 0.45 and 0.75 mm; 2) variation in the loading rate between 7.4 and 9.8 cm/min has very little effect on the efficiency of filters in removing nematodes; 3) about 55-60 percent of the mobile nematodes will pass through the filters operated as conventional rapid sand filters; 4) nematodes in soil can be activated for such experiments.

SECTION XXII

WATER QUALITY MANAGEMENT AND PROTECTION

WATER QUALITY CONTROL (Group 05G)

68-69:05G-001
DEGRADATION OF WATER QUALITY IN IRRIGATION RETURN FLOWS,
Law, J. P., Jr., Davidson, J. M., and Read, L. W.
Robert S. Kerr Water Research Center, Ada, Oklahoma.
Oklahoma State University, Agricultural Experiment Station Bulletin B-684, October 1970. 26 p, 7 fig, 6 tab, 27 ref, 1 append.
(See 68-69:02G-069)

68-69:05G-002
CHLORIDE CONTROL - ARKANSAS AND RED RIVER BASINS,
De Geer, M. W., and Ball, J. C.
U.S. Dept of the Army, Tulsa, Oklahoma, District Corps of Engineers.
Journal of the Sanitary Engineering Division, ASCE, Vol. 94, No. SA1, p 117-128, February 1968. 6 fig, 2 tab.

Descriptors: *Water quality, *Water supply, *Sanitary engineering, Chlorides, Control systems, Experimentation, Injection.

Natural brine emissions are found to be the principal cause of water quality degradation in the Arkansas and Red River Basins. The methods used to identify the brine emission sources are discussed and the pollution problem is expressed in terms of daily flows of thousands of tons of salt past major cities in the basins. Alternative control solutions considered during the planning studies are discussed and some selected control plans are presented. The value of proposed control works is evaluated in terms of reduced chloride concentrations in major reservoirs. Also presented are proposals for experimental field work needed as a first step leading to final design of control works.

68-69:05G-003
DRAIN INSTALLATION FOR NITRATE REDUCTION,
Willardson, L. S., Meek, B. D., Grass, L. B., Dickey, G. L., and Bailey, J. W.
Agricultural Research Service, Brawley, California.
Presented at the 1969 Winter Meeting, American Society of Agricultural Engineers, December 9-12, 1969, Chicago, Illinois, Paper No. 69-734. 8 p, 2 fig, 2 tab.

Descriptors: *Nitrate, *Drains, *Denitrification, Saturated soils, Water quality, Water pollution sources, Anaerobic conditions, Path of pollutants, *Drainage water, Drainage effects, Tile drainage, Soil water, Soil water movement.
Identifiers: Panoche silty clay, *San Joaquin Valley.

The soil is a Panoche silty clay. Six lateral lines of 6-inch concrete pipe were installed in a grid pattern in the test field. Two each of the individual lateral lines were installed at three depths: 6 feet, 7½ feet, and 9 feet. At the sump, an elbow overflow outlet was installed on the main collector line which controlled the ground water surface in the field at a depth of 6 feet. Samples of the drain tile effluent and atmosphere were taken at 3 locations along each drain. At two locations on each drain, 8 samples at different points on the exterior of the drain were taken. Soil solution samples were taken near the drains and at the 1/3 point between the drains at depths of 4½, 6, 7½ and 9 feet. At the 9-foot depth, the highest nitrate readings are around the bottom of the drain. The 7½ foot depth shows relatively high nitrate all around the drain, while the 6-foot drain shows low nitrate content around the top of the drain and high readings at the bottom. Dilution and denitrification were responsible for the reduced nitrate reading over the 6 and 9 foot drains. The electrical conductivity remained relatively constant and the nitrate level decreased in the outflow water from the total plot. This change indicates that submergence of the drains is resulting in denitrification in the field.

68-69:05G-004
IRRIGATING WITH ANIMAL WASTE,
Underwood, C.
Soil Conservation Service, Hermiston, Oregon.
Soil Conservation, p 81-82, November 1968.

Descriptors: *Farm wastes, *Irrigation, Groundwater, *Water pollution, *Irrigation practices, *Fertilizers, *Waste disposal, Farm lagoons, Organic wastes, Odor.

The use of an irrigation system as a means of disposal of the animal waste from a hog-raising facility is described. Effluent was pumped from the large pond directly into the sprinkling system. Systematic management determines which field gets the liquid fertilizer. The result showed that the sprinkler sewage disposal system fertilizes soil without pollution.

68-69:05G-005
SAN FRANCISCO BAY - DELTA WATER QUALITY CONTROL PROGRAM,
Walsh, R.
San Francisco Bay - Delta Water Quality Control Program, Sacramento, California.
Journal of the Water Pollution Control Federation, Vol. 40, No. 2, p 241-251, February 1968.

Descriptors: *Water resources, *Water quality control.
Identifiers: Agricultural drainage, *Water quality program, *San Francisco Bay, California, San Joaquin Delta.

San Francisco Bay and the Sacramento-San Joaquin area comprise one of the most rapidly developing areas in the country. Existing and planned water project developments together with agricultural drainage waters all have an effect on the area. The program, now being conducted by the State of California and to be completed in 1969, will develop the basic features of a comprehensive plan for the control of water pollution including a system for the collection, reclamation, treatment, and disposal of waste and drainage water discharges. This project, perhaps the largest and most comprehensive ever undertaken, is unique in several aspects - area size, complexity of hydrological system, diversity of the beneficiaries, and methods of approach.

68-69:05G-006
DRAINAGE DESIGN FOR MANAGING SALINE POLLUTANTS,
Winger, R. J., Jr.
Bureau of Reclamation, Denver, Colorado.
Paper presented at the 1969 Winter Meeting, American Society of Agricultural Engineers, Chicago, Illinois, Sherman House, Paper No. 69-735, December 9-12, 1969. 20 p, 4 fig, 4 tab, 7 ref.

Descriptors: *Drainage, *Drainage engineering, Drainage practices, Pollution, Water pollution, *Water pollution sources, Salts, Drainage systems, Tiles, Drainage water, Desalination, *Saline water.
Identifiers: *Donnan equation, Transient equation.

Management of the quality of subsurface drain effluent from irrigated lands in the western United States can be accomplished by: (1) constructing deep, widely spaced subsurface pipe drains with pipe and lined collectors terminating at a desalting plant; (2) constructing shallow, closely spaced subsurface pipe drains which skim off the better quality ground water, leaving the more saline ground water in storage. A drainage system design using transient and steady state methods for determining drain spacings when salinity control is considered is demonstrated by sample calculations.

68-69:05G-007
RECOVERY OF DIFFERNETIALLY PLACED NO_3-N IN A SILT LOAM SOIL BY FIVE CROPS,
Dancer, W. S., and Peterson, L. A.
Wisconsin University, Madison, Dept of Horticulture.
Agronomy Journal, Vol. 61, No. 6, p 893-895, November-December 1969. 1 fig, 3 tab, 14 ref.

Descriptors: *Nitrogen, Crops, Corn, Beans, Tobacco, Loam.
Identifiers: Nitrogen recovery.

Placement of NO_3-N at soils depths of 8, 23, 38, 53, and 69 cm was accomplished by an injection method with minimum disturbance to plant roots and to the soil profile. Utilization of the differentially placed NO_3-N by five crops for two cropping seasons indicated that these crops varied in their ability to recover the NO_3-N. Lima beans (Phaseolus lunatus L.) and green beans (Phaseolus vulgaris L.) obtained most of their N from the plow layer; while corn (Zea mays L.), tobacco (Nicotiana tabacum L.), and red beets (Beta vulgaris L.) recovered NO_3-N equally well from either the plow layer or the subsoil.

68-69:05G-008
PHOSPHORUS ADSORPTION SITES IN SOILS,
Harter, R. D.
Connecticut Agricultural Experiment Station, New Haven.
Soil Science Society of America Proceedings, Vol. 33, No. 4, p 630-632, July-August 1969. 3 tab, 10 ref.

Descriptors: *Phosphorus, *Adsorption, Organic matter.
Identifiers: NH_4F and NaOH extractable phosphorus.

Regression analysis of phosphorus adsorption as a function of five soil characteristics indicates that organic matter is important in the initial bonding of phosphorus by soils. It is, therefore, proposed that phosphorus is initially bonded to anion exchange sites on organic matter, and subsequently transformed into less soluble iron and aluminum phosphates.

68-69:05G-009
DENITRIFICATION AS A NITROGEN SINK IN LAKE MENDOTA, WISCONSIN,
Brezonik, P. L., and Lee, G. F.
Wisconsin University, Madison, Water Chemistry Laboratory.
Environmental Science & Technology, Vol. 2, No. 2, p 120-125, February 1968. 5 fig, 2 tab, 19 ref.

Descriptors: *Denitrification, Nitrates, Hypolimnion, Nitrogen cycle, Sediment, Sinks, Nitrite, Ammonia.
Identifiers: Lake Mendota.

The significance of denitrification as a sink in the nitrogen budget has been determined for Lake Mendota, Wis. About 28,100 kg of nitrogen were lost from the lake hypolimnion during the summer of 1966. However, this relatively large amount represented only about 11% of the estimated total annual nitrogen input. Denitrification rates ranged from 8 to 26μg. of N per liter per day, while rates of nitrate reduction (to ammonia and organic nitrogen) were found by ^{15}N tracer techniques to range from 1.4 to 13.4μg. of N per liter per day in the hypolimnion of the lake. Nitrate depletion is more than an order of magnitude slower than oxygen depletion in the hypolimnion of Lake Mendota, and denitrification is probably not significant with respect to respiration and catabolic processes in the lake hypolimnion. There is some evidence to indicate that dissolved nitrogen gas concentrations increase above those expected on the basis of solubility as the result of denitrification. Evaluation of various nitrogen sinks for Lake Mendota has revealed that only about one third of the estimated annual nitrogen input can be accounted for by currently evaluated sinks. Sediment deposition probably accounts for most of the remaining two thirds.

68-69:05G-010
CHEMISTRY OF THE SAN JOAQUIN RIVER SYSTEM UNDER BASE FLOW CONDITIONS,
Nightingale, Harry I., and Behnke, Jerold J.
Agricultural Research Service, Fresno, California.
Journal of the American Water Works Association, Vol. 61, No. 8, p 382-386, August 1969. 5 fig, 7 ref.

Descriptors: *Water quality, *Streamflow, *California, *Rivers, *Water chemistry, Solutes, Groundwater, Water analysis, Irrigation water, Reservoirs, Springs, Lakes, Precipitation (Atmospheric).
Identifiers: *San Joaquin River.

A water quality survey was made of the San Joaquin River, California, from its origin in the Sierra Nevada to its entry into the east side of the San Joaquin Valley. The base flow of the river system is considerably modified by dams, diversion tunnels, and pipelines for power projects, flood control, and irrigation, all of which alter water quality. From an irrigation standpoint, the quality of all the waters sampled within the San Joaquin River System (with the exception of West Chiquito Creek) was excellent. Although the salt content of the waters was quite low and all the waters were derived from essentially granitic terrain, marked chemical differences did exist between the source lakes and the river tributaries. Mammoth Pool contained more dissolved salts in somewhat different proportions than Huntington and Shaver Lakes. This difference is probably attributable to the fact that some of the higher drainage areas associated with Mammoth Pool contain volcanic and metavolcanic rocks and associated thermal springs, whereas the drainage basins for the 2 other lakes are composed almost exclusively of granitic material. The chemical differences observed in the tributary streams were generally attributed to differences in rock type in the drainage basin, groundwater return flow, or unusual spring discharges. There is approximately an increase in salinity of 6.2 in the water of the San Joaquin River System from its snow origin in the high Sierra Nevada to the eastern edge of the San Joaquin Valley. Most of the salinity increase takes place when the water infiltrates below the ground surface. The displacement of high quality lake waters by tunnels and pipes for hydroelectric power generation has probably improved the chemistry of the river by maintaining a firm base flow composed of high quality water stored in the Sierra Nevada lakes.

68-69:05G-011
COMMENTS ON 'RECREATION BENEFITS FROM WATER POLLUTION CONTROL',
Burt, Oscar R.
Montana State University, Bozeman.
Water Resources Research, Vol. 5, No. 4, p 905-907, August 1969. 1 fig, 6 ref.

Descriptors: *Water pollution control, *Water pollution, *Benefits, Demand, Sport fishing, Recreation demand, Social values, Recreation, Costs, Recreation facilities, Prices, Cost-benefit analysis.
Identifiers: *Recreation benefits, *Consumer surplus, Willingness to pay, Marginal social value, Marginal social cost, Gross benefits, Gross social value.

The author comments on an article and note by Joe B. Stevens pertaining to two alternative measures of benefits associated with water pollution control in a sport fishery. The purpose of this note is to present a third measure and to show that the other two measures are of doubtful logical validity. The two measures of benefits attributable to pollution prevention by Stevens he calls (1) increased consumer surplus and (2) increased willingness to pay. The definition of consumer surplus was taken from Marshal and willingness to pay from Marglin. Stevens' analysis is applied to a graph showing two demand curves: D sub o corresponding to low pollution and D sub 1 corresponding to high pollution. In Stevens' note he is only concerned with a procedure for measuring the gross benefits of pollution control. Stevens apparently felt it necessary to infer social value from only D sub 0 and used D sub 1 only to determine quantity taken at a zero price under polluted conditions. The author feels that the discrepancy in benefits associated with pollution control that Stevens found when using the two criteria is a result of his dubious method of applying the two criteria. The author then presents a generalized framework for analysis which permits evaluation of pollution control under the assumption of optimum pricing. Here, the difference in net values associated with polluted and unpolluted water measures the social reward from pollution control when recreation facilities are optimally priced. This net social value could then be compared with the initial investment cost of pollution control in some sort of benefit-cost framework.

68-69:05G-012
QUALITY OF SURFACE WATERS FOR IRRIGATION, WESTERN STATES-1961,
Love, S. K.
Geological Survey, Washington, D.C.
Geological Survey Water-Supply Paper No. 1886, 1968. 154 p, 2 fig, 1 plate, 18 ref, index.

Descriptors: *Water quality, *Irrigation water, *Data collections, Streamflow, Hydrologic data, Water chemistry.
Identifiers: *Western US, Water quality data.

Water chemical quality and streamflow data of 1961 are compiled for 73 irrigation network stations west of the Mississippi River. Stations are listed with dates of operation. Each quality record includes station location, drainage area, a list of available records, extreme values of specific conductance and sodium content, and periodic records of runoff, silica, Ca, Mg, Na, K, bicarbonate, carbonate, sulfate, Cl, F, nitrate, B, total dissolved solids, %Na, SAR, specific conductance, and pH.

68-69:05G-013
REMOVAL OF SALINE WATER FROM AQUIFERS,
Carlson, E. J.
Bureau of Reclamation, Denver, Colo. Office of Chief Engineer. 14 p, 4 fig, 1 tab, 16 ref.

Descriptors: *Saline water-fresh-water interfaces, *Leaching, *Saline water systems, *Groundwater movement, Drainage systems, Hydraulic models. Mathematical models, Aquifers, Model studies, Drainage programs, Subsurface drainage, Water management (Applied).
Identifiers; Aquifer sweetening, Aquifer desalination.

Aquifer desalting was studied in a rectangular, glass-walled, sand-filled tank and in a mathematical model. Two types of aquifers were studied: (1) a 1:40 scale, two-part aquifer (course and fine sand) representing a vertical cross section through an idealized protion of an irrigated valley; and (2) a fine sand, single-part aquifer used to evaluate a formula derived from the Ghyben-Herzberg principle for computing depth to a saline-fresh water interface. Salt water was flushed from the aquifers into subsurface drains by applying fresh water to the surface. Test results for both aquifer types showed that tile drains placed near the ground surface will not intercept and discharge surface-applied fresh water if all or part of the aquifer contains salt water. The fresh water displaces the salt water without appreciable mixing and moves it into the drains. A stable fresh-salt water interface is thereby formed in the aquifer. Reduced spacing of drains reduced the amount of salt water that will be removed from the aquifer. Progress of the tests was recorded in still and timed-sequence motion pictures.

SECTION XXIII

WATER RESOURCES PLANNING - TECHNIQUES OF PLANNING (Group 06A)

68-69:06A-001
CONSTRUCTION OF PIPE DRAINS ON THE COLUMBIA BASIN PROJECT,
Monteith, J., and Myers, P. M.
Columbia Basin Project, Ephrata, Washington.
Paper presented at the 1968 Annual Meeting of the American Society of Agricultural Engineers, Utah State University, Logan, Utah, June 18-21. 11 p.

Descriptors: *Subsurface drains, *Investigation, *Design, *Inspection, Planning, *Construction, Equipment.
Identifiers: *Columbia Basin.

Experience in constructing 400 miles of subsurface pipe drains in seven years has influenced present methods which are reported. Nearly all of the work has been done by contract. Planning, investigation, design, preparation of specifications, construction work, and inspection, with associated problems, are discussed. Recently, machinery has been used to dig a ten foot trench, lay pipe, and place gravel in one pass, at a rate of as much as 2,000 feet in eight hours.

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SECTION XXIV

WATER RESOURCES PLANNING - EVALUATION PROCESS (Group 06B)

68-69:06B-001
TOWARDS ECONOMIC EVALUATION OF THE QUALITY OF WATER IN IRRIGATION,
Yaron, Dan.
Hebrew University, Jerusalem (Israel), Dept of Agricultural Economics.
Water For Peace, Vol. 6, p 749-757, 1967. 2 fig, 1 tab, 13 ref.

Descriptors: *Irrigation water, *Water quality control, Salt balance, Statistical methods, *Water supply, *Water demand.
Identifiers: *Saline water systems, Evaluation.

Water quality is controllable. Therefore, the quantity and quality of water should be considered as economically meaningful parameters in water resource development or management decisions. The effects of irrigation with saline water on crop yields are reviewed. Next, a highly simplified economic model, which optimizes possible quantity - quality combinations within a framework of the supply and demand for irrigation water is presented. In making this model more realistic, the supply side is treated only indirectly but the distinction is explicitly made between the supply and demand. The major portion of this paper deals with the evaluation of the quality of water in irrigation.

68-69:06B-002
WATER QUALITY MANAGEMENT AND THE TIME PROFILE OF BENEFITS AND COSTS,
Parker, D. S., and Crutchfield, J. A.
Water Resources Engineers, Walnut Creek, California.
Water Resources Research, Vol. 4, No. 2, p 233-246, April 1968. 9 fig, 2 tab, 6 ref.
Descriptors: *Demand, *Benefits, *Planning, *Water quality, Social aspects, Projects, Water pollution.

Economists, in evaluating the long-term benefits in public works projects, have traditionally held that long-term benefits will contribute very little to the total present worth of the benefits accrued over the life of the project. It is shown, however, that the long-term social cost resulting from projects that cause water pollution cannot be neglected or assumed away in the host of practical cases where "amenity" demands for good water quality in a project's area of influence are significant.

68-69:06B-003
ECONOMICS OF WATER-YIELD FOR SUGAR CANE,
Hogg, H. C., Davidson, J. R., and Chang, Jen-hu.
Hawaii University, Honolulu, Economic Research Service.
Journal of the Irrigation and Drainage Division, American Society of Civil Engineers, Vol. 95, No. IR1, p 127-138, March 1969. 2 fig, 3 tab, 5 ref, 5 append.

Descriptors: *Economics, *Irrigation, *Irrigation practices, *Water balance, *Water demand, *Water yield, Evaporation pans, Management, Sugar cane.

An aggregate water deficiency model developed to isolate the relationship between water and sugar cane yield is presented along with the empirical results of a specific application to plantation data. The usefulness of the model as a basis for dealing with a number of economic problems in irrigation management is demonstrated in both a theoretical and empirical analysis.

68-69:06B-004
INTERDISTRICT APPORTIONMENT OF FLOOD CONTROL COSTS,
Dague, R. R., Baumann, E. R., and Morgan, P. E.
Iowa University, Iowa City, Dept of Civil Engineering.
Journal of the Irrigation and Drainage Division, American Society of Civil Engineers, Vol. 94, No. IR4, p 441-454, December 1968. 6 fig, 1 tab, 2 ref.

Descriptors: *Drainage, *Flood control, *Legislation, Cost-benefit analysis, Costs, Assessments, Taxes.
Identifiers: Litigation.

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Engineers are often called upon to apportion the costs of improvement works among benefiting users. In some cases, the procedures for making the apportionment are established. In other cases, legal statutes or engineering experience provide little information on apportionment procedures. One such case is the assessment of the costs of flood-control improvements among several drainage districts on a river basin. The Statutory Code of the State of Iowa (USA) enables a part of the cost of flood control work in downstream districts to be assessed to upstream districts. The Code states that the costs shall be assessed "...in porportion to the benefits derived." How is the engineer to determine the relative benefits? The writers considered the physical characteristics of the basin to arrive at a formulation intended to reflect relative benefits. The benefit factors are used to calculate dollar assessments. It is concluded that the development of any "formula" for assessing drainage benefits must represent a balance between the theoretical and the practical, the tangible and the intangible, and previous experience.

68-69:06B-005
TECHNOLOGICAL CHANGE AND THE ECONOMICS OF CONSERVATION,
Rosenberry, P. E., Daugherty, A.B., and Pavelis, G.A.
Economic Research Service, Ames, Iowa
Journal of Soil and Water Conservation, Vol. 23, No. 4, p 123-126, July-August, 1968.
10 ref.

Descriptors: *Conservation, *Economics, Erosion control, Soil conservation, Water conservation, Adoption of practices, Terraces, Land resources, Resources, Land Management, Land farming.

To achieve desired levels of conservation, economic principles of allocating soil and water resources over time must be considered thoroughly, along with elements of good engineering practice, in planning, designing and installing conservation measures. Before this goal is achieved, certain challenges must be met: (1) behavioral riddles of nonacceptance of apparently "profitable" conservation farming systems must be solved; (2) the cost-benefit relationship of specific conservation practices on a regional and local level must be established for use in selecting appropriate measures; (3) relationships between the total social benefits and the on-site, short run benefits accruing to the farmer must be established for use in determining appropriate private-public cost sharing arrangements. The income elasticities of demand for food and other consumptive goods puts the farmer in a cost-price squeeze in relation to industrial managers. Technology has enabled the farmer to substitute capital for labor to the extent that it now represents 75 percent of all agricultural resource inputs. In general, the farm and ranch units have increased in size and thus the emphasis is on timeliness of operation, to larger equipment and higher efficiencies. Conservation measures which improve efficiencies are favored, while those which interrupt operations are disliked.

68-69:06B-006
SIMULATION AND MODELING TECHNIQUES,
Young, D.F.
Iowa State University, Ames.
Transaction of the American Society of Agricultural Engineers, Vol. II, No. 4, p 590-594, July-August, 1968. 5 fig, 11 ref.

Descriptors: *Model studies, Simulation, Mathematical models, Design, Agricultural Engineering, Dimensional analysis.

There is little doubt that the technique of simulation has been, and will continue to be, applied successfully not only in research but also in design and analysis. In this paper the emphasis has been placed on the use of similar models because of their widespread applicability in agricultural engineering. Since the general theory is well known, attention has been given to some of the problems that are known to arise in the establishment of similarity parameters. One of the greatest shortcomings commonly encountered in the use of similar models is the incomplete analysis of the problem, whereas no formal and well-defined procedure is used to establish the similarity requirements. It is simply done on the basis of past experience and intuition. Frequently this leads to valid results because of a great accumulation of experience, but also it can readily lead to erroneous results so that the application of a standard formal procedure in the development of similarity requirements is recommended. One of the major advantages of using dimensional analysis over other simulation techniques is that the characteristic equations for the system do not have to be formally derived. However, it is clear that a combination of theory and dimensional analysis provides a more effective tool, even if the problem is to be studied experimentally.

SECTION XXV

WATER RESOURCES PLANNING

COST ALLOCATION, COST SHARING, PRICING/REPAYMENT (Group 06C)

68-69:06C-001
TOWARDS ECONOMIC EVALUATION OF THE QUALITY OF WATER IN IRRIGATION,
Yaron, Dan.
Hebrew University, Jerusalem (Israel), Dept of Agricultural Economics.
Water For Peace, Vol. 6, p 749-757, 1967. 2 fig, 1 tab, 13 ref.
(See 68-69:06B-001)

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SECTION XXVI

WATER RESOURCES PLANNING - WATER LAW AND INSTITUTIONS (Group 06E)

68-69:06E-001
ECONOMIC ISSUES IN CONTROLLING AGRICULTURAL POLLUTION,
Taylor, G. C.
Economic Research Service, Washington, D.C.
Paper presented at the American Agricultural Economics Association Meetings, Lexington, Kentucky, August 19-20, 1969. 12 p, 14 ref.
(See 68-69:05A-004)

68-69:06E-002
WATER RIGHTS LITIGATION,
Taylor, Edward F.
City Attorney, Redlands, California.
Journal of the American Water Works Association, Vol. 58, No. 5, p 535-554, May 1966. 54 ref.

Descriptors: Droughts, Water conservation, Interstate, Water supply, *Delaware River Basin Commission, *Interstate compacts, State governments, Municipal water, *Water permits, Riparian rights, Prior appropriation, Water pollution control, *Long-term planning, Local governments.
Identifiers: Water impasse, Model Water Use Act.

The drought that seized the Northeast in 1965, and which regularly seizes the West, pointed out the need for water laws of national and regional scope, but, more importantly, for farsighted local plans. The states of New York, New Jersey, and Delaware launched long-range attacks on the problem of water supply and conservation through the Delaware Basin Commission. Local government's primary responsibility is to protect and develop water supplies. Determining who has priority is the key in developing comprehensive rules to govern the use of water. The Model Water Use Act is a major aid in water-law revision as it incorporates the most workable provisions of many state and local systems. Western water law is the article's main topic.

68-69:06E-003
INSTITUTIONAL FACTORS AFFECTING LAND AND WATER DEVELOPMENT, LOWER RIO GRANDE VALLEY, TEXAS,
Trock, Warren L.
Texas A&M University, College Station.
Water Resources Research, Vol. 5, No. 6, p 1364-1366, December 1969. 1 ref.

Descriptors: *Water resources development, *Institutional constraints, *Water law, *Water rights, *Rio Grande, Land management, Water management (Applied), Political constraints.
Identifiers: Lower Rio Grande Valley (Texas).

Among the many institutional factors that complicate land and water development in the lower Rio Grande Valley are (1) uncertainties in water rights, (2) a proliferation of special districts, (3) inappropriate water management policies among districts, and (4) numerous governmental entities involved in planning and administering water resources. It is recommended that the people of the valley urge and facilitate an early adjudication of rights. Improvements in irrigation and drainage could be achieved by reorganizing the special districts. A master district for the three-county area may be a logical alternative to the many districts that now exist. Rehabilitation of irrigation systems, including installation of water meters, will contribute to the management of water supplies.

68-69:06E-004
LIAISON - KEY TO HIGHWAY AND AGRICULTURAL DRAINAGE PROGRAMS,
Drablos, Carroll J. W., and Jones, Benjamin A., Jr.
Illinois University, Urbana, Dept of Agricultural Engineering.
Journal of the Irrigation and Drainage Division, American Society of Civil Engineers, Vol. 95, No. IR1, p 185-197, March 1969. 1 fig, 3 ref.

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Descriptors: *Agriculture, *Drainage, Legislation, Highways, Water laws.
Identifiers: Liaison programs.

The solution of highway and agricultural drainage problems requires knowledge of engineering practices and laws enacted by a particular jurisdiction. However, many of the problems that exist today have been the result of a lack of understanding or willingness of the various interests to accept their legal responsibilities rather than a lack of technical knowledge. Communication or the exchange of ideas and information is essential so that the highway authority can acquaint the landowners with proposed highway improvements at an early stage of planning and also learn their plans for conservation and drainage improvements. The development of a medium of understanding between the various agencies, organizations, and landowners involved is the first step in solving mutual problems. Then the outlining of specific lines of communication is necessary if each agency is to fulfill its responsibilities. This paper presents some experience and suggests some procedures to follow to meet the challenge for better solutions to highway and agricultural drainage problems.

RESOURCES DATA - NETWORK DESIGN (Group 07A)

68-69:07A-001
CHEMICAL MEASUREMENT OF MEAN TEMPERATURE,
Lee, Richard, and Jones, E. B.
Pennsylvania State University, University Park.
Water Resources Bulletin, Vol. 4, No. 4, p 39-45, December 1968. 3 fig, 1 tab, 8 ref.

Descriptors: *Temperature, *Hydrolysis, *Data collections, *Methodology, Analytical techniques, Heat budget, Hydrologic aspects, Solar radiation, Evaporation, Consumptive use, Thermal pollution, Climatology, Pennsylvania, Irrigation.
Identifiers: *Mean temperature, *Chemical method.

The significance of mean temperature to hydrology, methods of integrating temperature over time, problems involved, and appropriate application areas for the chemical mean temperature method are discussed. A versatile methodology, based on the temperature dependence of sucrose hydrolysis, was tested in Pennsylvania. The technique permits low-cost mass sampling of air, water, and soil temperatures. Because the sensing elements are transparent, short-wave radiation effects are negligible. In field tests duplicate sensors yield repeatedly the same values plus or minus 0.02 deg C. Data can be related directly to measurements obtained in standard climatological networks. The technique has good application in such hydrological studies as evaporation, consumptive use, thermal pollution, and soil moisture in irrigation practices.

SECTION XXVIII

RESOURCES DATA - DATA ACQUISITION (Group 07B)

68-69:07B-001
PRELIMINARY FIELD STUDIES USING EARTH RESISTIVITY MEASUREMENTS FOR DELINEATING ZONES OF CONTAMINATED GROUND WATER,
Warner, D. L.
Federal Water Pollution Control Administration, Ohio Basin Region.
Groundwater, Vol. 7, No. 1, p 9-16, January-February, 1969. 7 fig, 10 ref.
(See 68-69:05B-024)

68-69:07B-002
SOIL PREPARATION AND SAMPLING TECHNIQUES FOR STUDYING ION MOVEMENT,
Khasawneh, F. E., and Soileau, J. M.
Tennessee Valley Authority, Muscle Shoals, Alabama
Soil Science Society of America Proceedings, Vol. 33, No. 3, p 476-477, May-June 1969. 3 fig, 5 ref.

Descriptors: *Sampling, *Diffusion, *Ion transport.
Identifiers: *Soil column sectioning, *Ped coatings.

Techniques are described for preparing and sampling soil columns and undisturbed soil peds used for ion movement studies. These methods utilize a block of paraffin wax-petrolatum jelly mixture to hold soil peds or to provide a cylindrical cavity for a soil column. A microtome and holder apparatus capable of holding the wax blocks containing the soil is used for precision slicing at increments of 0.5 mm or more.

68-69:07B-003
MEASURING THE HYDRAULIC POTENTIAL OF GROUND WATER WITH THE HYDRAULIC POTENTIAL PROBE,
Fokkens, B., and Weijenberg, J.
Land Improvement and Reclamation Company, De Bilt (Netherlands).
Journal of Hydrology, Vol. 6, No. 3, p 306-313, 1968. 3 fig, 2 tab, 2 ref.

Descriptors: *Ground water, *Saturated soils, Time lag, Piezometers.
Identifiers: *Potential probe.

The "potential probe," which was used by the authors during two years on a rather large scale, is a new instrument to measure hydraulic potentials in saturated soils without disturbing the soil profile. A second advantage is that the basic time lag of the apparatus is about 15 times shorter than that of normal one inch tube piezometers.

68-69:07B-004
HYDRAULIC CONDUCTIVITY MEASUREMENTS WITH A PRESSURE TRANSDUCER,
Overman, A. R., Peverly, J. H., and Miller, R. J.
Illinois University, Urbana, Dept of Agronomy.
Soil Science Society of America Proceedings, Vol. 32, No. 6, p 884-886, November-December 1968. 2 fig, 6 ref.

Descriptors: *Hydraulic conductivity, *Permeameters, *Permeability, Clay, Saturated flow.

A rapid method for measuring hydraulic conductivities of materials in the range 10^{-6} to 10^{-10} cm/sec is described. By using a pressure transducer as part of a decreasing head permeameter, the time constant for measurement is reduced. Only small volume transfers of water are required. An example is discussed to illustrate the method.

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68-69:07B-005
LEAF SAMPLER FOR RELATIVE WATER CONTENT MEASUREMENTS: DESIGN AND APPLICATION,
Brown, R. W.
Forest Service, Ogden, Utah, Intermountain Forest and Range Experiment Station.
Agronomy Journal, Vol. 61, No. 4, p 644-647, July-August 1969. 3 fig, 11 ref.

Descriptors: *Evaporation, *Moisture content, *Plant tissue, *Wilting, *Turgidity.
Identifiers: *Leaf sampler, *Leaf cutter.

A leaf sampler capable of holding eight samples has been designed and used for measuring the relative water content of plant tissues. The precision-made leaf cutter and sample chambers permit the collection of leaf tissue disks from leaves still attached to the plant. After excision, tissue samples can be sealed immediately in small vials within the sample chambers to prevent evaporative water loss. Relative water content values of orchardgrass leaf samples obtained with the leaf sampler were higher, without exception, than were the values of similar samples obtained with a cork borer. However, these differences were not significant until permanent wilting was approached.

68-69:07B-006
A SIMPLE, TENSION-FREE LYSIMETER,
Jordan, C. F.
Puerto Rico Nuclear Center, Rio Piedras.
Soil Science, Vol. 105, No. 2, p 81-86, 1968. 5 fig, 4 tab, 7 ref.

Descriptors: *Lysimeter, Instrumentation, Soil water, Water loss, *Percolation, Potassium, Calcium, Soil types, *Podsols, Soil horizons.
Identifiers: Lakewood sand, *"Zero-Tension" lysimeter.

The "Zero-Tension" lysimeter can be installed in almost any type of soil, and the problem of surface tension, common to many lysimeters, is eliminated. It was tested in Lakewood sand, a podsol soil in New Jersey. When light precipitation occurred, element concentration in the water collected from the A and C horizons was high, but the B horizon and the underlying glauconite bearing bed had soil water low in element content. During heavy storms, however, element concentration in water from the B and glauconite horizons was higher than from the A and C. Potassium and calcium moved into solution more rapidly than iron in the podsol A horizon, but iron moved out more rapidly in the B. A large difference in total quantity of elements moving into A horizon lysimeters occurred between two areas both mapped as Lakewood sand. The area with the greater element movement had a coarser texture, and the A horizon extended deeper.

68-69:07B-007
A RAPID METHOD OF SOIL MOISTURE DETERMINATION,
Prihar, S. S., and Sandhu, B. S.
Punjab Agricultural University, Hissar,India.
Soil Science, Vol. 105, No. 3, p 142-144, 1968. 1 fig, 1 tab, 4 ref.

Descriptors: *Soil moisture, *Instrumentation, *Moisture content, Soil moisture meters, Soil water, Soil density.
Identifiers: Flask, Oven-dry method.

A two-piece, 100-ml. glass flask has been devised for rapid determination of soil moisture. The principle involved is the variable increase in the known volume of liquid with the addition of a soil sample of varying moisture contents. The increase in volume is measured in the calibrated tubular stopper of the flask. Moisture contents of ten soils were determined simultaneously using oven-dry methods and the flask method. The soils ranged from fine sand to clay loam with pH from 5.3 to 8.5, organic carbon from 0.2 to 0.8 percent and moisture contents varying from 2.6 to 36.8 percent. Ninety percent of the values with the flask are within ±1.0 percent moisture difference from the oven-dry values. Regression equations computed for four soils and collectively for all soils are almost identical. Therefore, the new method can be said to be equally applicable to the range of soils studied.

68-69:07B-008
A CORING DEVICE FOR UNCONSOLIDATED LAKE SEDIMENTS.
Schneider, R. F.
Southeast Water Laboratory, Athens, Georgia.
Water Resources Research, Vol. 5, No. 2, p 524-526, April 1969. 1 fig, 4 ref.

Descriptors: *Lake soils, *Sediment, *Cores, Sampling, Lakes, Ponds, Pipes, Pistons.
Identifiers: *Livingston corer.

A piston-type coring device for unconsolidated bottom deposits is described. The apparatus is a modification of the lightweight Livingstone corer. The coring tube is clear plastic, allowing visual examination of the core before extrusion, and the piston contains a vacuum release tube to prevent expansion of the cored material during removal of the piston. It is easily constructed, requiring no special machining, and is therefore relatively inexpensive compared with other similar coring devices.

68-69:07B-009
SOIL MOISTURE MEASUREMENT BY THE GAMMA TRANSMISSION METHOD,
Ryhiner, A. H., and Pankow, J.
Institute for Land and Water Management Research, Wageningen (Netherlands).
Journal of Hydrology, Vol. 9, No. 2, p 194-205, October 1969. 8 fig, 2 tab, 3 ref.

Descriptors: *Nuclear moisture meters, *Gamma rays, *Calibrations, Soil moisture meters, Instrumentation, Density, Soil moisture, Soil water.
Identifiers: Gamma-transmission soil moisture meters.

A discussion is given of the use of the gamma transmission method for the measurement of soil moisture variations. It is shown that a single calibration curve can be used for very different soils. An approach is presented for the determination of the build-up factor of scattered radiation and for the instrumental resolution time. It appeared possible to calculate the systematic errors due to non-parallelism of the access tubes.

68-69:07B-010
THE CALCULATION OF NON-PARALLELISM OF GAMMA ACCESS TUBES, USING SOIL SAMPLING DATA,
Rijtema, P. E.
Institute for Land and Water Management Research, Wageningen (Netherlands).
Journal of Hydrology, Vol. 9, Nol 2, p 206-212, October 1969. 3 tab, 1 ref.

Descriptors: *Nuclear moisture meters, *Gamma rays, *Calibrations, Soil moisture meters, Instrumentation, Density, Soil moisture, Soil water.
Identifiers: Gamma-ray moisture meters, Access tubes.

An equation has been derived to determine the errors due to non-parallelism of gamma access tubes with the aid of soil sampling data, taken from the direct environment of the measuring spot. It is shown that the determination of the change in moisture content is not very sensitive to errors due to non-parallelism. When the absolute values of moisture content are needed, it is always necessary to determine the errors due to non-parallelism of the access tubes.

68-69:07B-011
CALIBRATION AND EVALUATION OF A WIDE-RANGE GRAVIMETRIC METHOD FOR MEASURING MOISTURE STRESS,
McQueen, Irel S., and Miller, Reuben F.
Geological Survey, Denver, Colorado.
Soil Science, Vol. 106, No. 3, p 225-231, 1968. 1 fig, 2 tab, 14 ref.

Descriptors: *Soil moisture, *Soil moisture meters, *Moisture tension, *Instrumentation, Calibrations, Soil water, Wettability, Hydrologic properties, Methodology.
Identifiers: *Stress sensor, Filter paper, Filters.

A method of determining the soil moisture stress of field samples by sealing pieces of filter paper into the sample container but not in contact with the sample is described. The samples and paper discs are allowed equilibrate at 20 deg C for at least a week. Samples must be handled with care; grain rearrangement changes moisture stress without change in water content. After equilibration, the paper is accurately and rapidly weighed. Moisture stress may be computed from the moisture content of the filter paper or it may be obtained from a calibration plot. The method is effective over a stress range of 0.001 to 1,500 bars. The accuracy is as good as or better than that of other commonly used methods.

68-69:07B-012
PIEZOMETER DETECTION OF SATURATED INTERFLOW IN SOILS,
Betson, Roger P., Marius, John B., and Joyce, Robert T.
Tennessee Valley Authority, Knoxville.
Soil Science Society of America Proceedings, Vol. 32, No. 4, p 602-604, July-August 1968. 1 fig, 1 tab, 3 ref.

Descriptors: *Piezometers, Instrumentation, Soil water, *Saturated flow, Watershed hydrology.

Piezometers were used as saturated interflow detection devices in a study of partial watershed contribution to storm runoff. Saturated interflow was detected along the AB-horizon interface in clay loam soils with shallow A horizons. The results of the study showed that at least under some soil conditions piezometers can be useful in determining the extent of saturated flow within a watershed. The occurrence of this flow will normally be confined to the shallow A-horizon regions.

68-69:07B-013
DESIGN AND PERFORMANCE OF AN OSMOTIC TENSIOMETER FOR MEASURING CAPILLARY POTENTIAL,
Peck, A. J., and Rabbidge, R. M.
Commonwealth Scientific and Industrial Research Organization, Canberra (Australia), Division of Plant Industry.
Soil Science Society of America Proceedings, Vol. 33, No. 2, p 196-202, March-April 1969. 11 fig, 9 ref.

Descriptors: *Soil moisture, *Soil water movement, Soil-water-plant relationships, Soil science, Soil physics, Soil chemistry, Soil properties, Soil investigations, Soil water, Unsaturated flow, Diffusion, Evapotranspiration, Infiltration, Lysimeters, Moisture tension.
Identifiers: *USSR.

Soil moisture, soil moisture movement, and soil properties are described in a comprehensive monograph of the present state of soil moisture science in the USSR. The approach to soil hydrologic studies in the USSR involves experiments and observations under field conditions, in which the soil layer is studied as a whole in its native state. The discussion of the water properties of soils is subdivided into porosity, water properties, sorption of water vapor, sorption of liquid water, suspended water, and free gravitational water. The discussion of soil water movement and soil-water-plant relationships is subdivided into thermodynamics, water motion, soil moisture and plants, and forms of soil moisture. The approaches to soil moisture studies in the US, Europe, and the USSR are described and compared.

68-69:07B-014
SIMULTANEOUS CYCLING OF PELTIER THERMOCOUPLE PSYCHROMETERS FOR RAPID WATER POTENTIAL MEASUREMENTS,
Hoffman, G. J., Herkelrath, W. N., and Austin, R. S.
U.S. Salinity Laboratory, Riverside, California.
Agronomy Journal, Vol. 61, No. 4, p 597-601, July-August 1969. 2 tab, 5 fig, 8 ref.

Descriptors: *Instrumentation, *Soil moisture meters, *Soil water, *Hygrometry.
Identifiers: *Thermocouple psychrometer scanner, *Soil water potential, Leaf water potential.

An automatic system was built to record the output from Peltier-effect thermocouple psychrometers. The system consists of a scanner, capacitors, voltmeter, and a recorder. The scanner, built from inexpensive commercial components, is of solid-state circuitry and contains only one moving mechanism, a stepping relay. The system automatically reads and stores the initial emf, cools as many as six psychrometers simultaneously, reads and stores the final emf, and heats the measuring junction of the psychrometers. For a 30-second cooling period, six psychrometers can be read in 2½ minutes. By adding a stepping relay, as many as 150 psychrometers can be read in an hour. The standard deviations for recorded calibration outputs were ±0.04μv for soil and intact leaf thermocouple psychrometers. Under actual experimental conditions, the values obtained with the automatic system were as accurate as measurements made manually.

68-69:07B-015
INSTALLATION OF SOIL MOISTURE ACCESS TUBES IN ROCKY SOILS,
Richardson, Bland Z.
Forest Service, Logan, Utah, Intermountain Forest and Range Experiment Station.
Journal of Soil and Water Conservation, Vol. 21, No. 4, p 143-145, July-August 1966.
3 fig, 9 ref.

Descriptors: *Drilling equipment, *Boreholes, *Moisture content, *Soil moisture meters, *Radioactivity, Neutron absorption, Wells, Soil types, Rocks, Rock properties, Rock excavation, Equipment.
Identifiers: *Access tubes, Wagon drill, Hand-held drill.

Drilling holes for soil moisture access tubes in a rocky soil mantle can, without proper planning and equipment, be the most costly, inefficient phase of soil moisture studies that employ neutron scattering methods. This paper discusses requirements for drilling satisfactory access tube holes in rocky soils. It describes and illustrates problems of drilling adequate holes with hand-held rock drills, tractor-mounted drills, and crawler-mounted drills; and compares the efficiency and cost of these methods. The most satisfactory access tube holes can be obtained by using a wagon-type rock drill mounted either on a tractor or self-propelled crawler. Their cost is only about one-sixth the cost of drilling holes with hand-held equipment.

68-69:07B-016
PIEZOMETER FOR MONITORING RAPIDLY CHANGING PORE PRESSURES IN SATURATED CLAYS,
Wolff, Roger G., and Olsen, Harold W.
U.S. Geological Survey, Washington, D.C.
Water Resources Research, Vol. 4, No. 4, p 839-843, August 1968. 6 fig, 5 ref.

Descriptors: *Piezometers, *Instrumentation, *Piezometry, *Water yield, Observation wells, Groundwater, Aquifers, Pressure, Aquicludes, Clays, Permeability.
Identifiers: Pore-pressure changes, Imperial College Piezometer, In situ calibration.

A rapid response piezometer used for measuring dynamic changes in pore water pressures in saturated clays in response to pumping adjacent aquifers is described. This measurement is part of a technique developed to determine quantities of water that are available from confining beds when pumping aquifers. The instrument, a modification of the Imperial College Piezometer, has rapid response, in situ calibration, high sensitivity unaffected by total pressure, rugged shock-resistant construction, and provision for continuous automatic recording. The piezometer was tested in clay loaded by a water column; test data are presented graphically.

68-69:07B-017
A SENSOR FOR WATER FLUX IN SOIL. 2. 'LINE SOURCE' INSTRUMENT,
Byrne, G. F., Drummond, J. E., and Rose, C. W.
CSIRO, Canberra, Australia, Division of Land Research.
Water Resources Research, Vol. 4, No. 3, p 607-611, June 1968. 3 fig, 2 ref.

Descriptors: *Instrumentation, *Flowmeters, Current meters, Thermometers, Electronic equipment, Research and development, Research equipment, Soil physics, Porous media.
Identifiers: *Water flux sensor, Differential thermometers, Water flux.

Two sensors are described that measure the flux of water in soil, or the flux of other fluids in any porous medium. The electrical output of such instruments can be of sufficient magnitude that a water flow velocity of .0001 cm/sec in soil is readily measured. The flow to be measured causes asymmetry in the temperature field generated by a line source of heat located centrally in the instrument. The temperature difference due to this asymmetry gives rise to the output of the instrument. A theoretical analysis of the temperature field is given for boundary conditions appropriate to each type of sensor. Theoretical and experimental calibrations agreed closely when assumptions in the theory were realized experimentally. The analysis was used to elucidate design principles and their effect on instrument performance.

68-69:07B-018
MEASURING SUBSURFACE SPRING FLOW WITH RADIOTRACERS,
Galegar, William C., and DeGeer, Myron W.
Federal Water Pollution Control Administration, Dallas, Texas.
American Society of Civil Engineers Proceedings, Journal of the Sanitary Engineering Division, Vol. 95, No. SA6, Paper No. 6973, p 1097-1103, December 1969. 4 fig, 2 ref.

Descriptors: *Tracers, *Tritium, *Groundwater movement, *Texas, *Springs, Streamflow, Tracking techniques, Leakage, Seepage, Water pollution sources, Brines, Saline water systems, Aquifers, Karst, Groundwater.
Identifiers: Estelline Spring (Texas).

A hydrostatic head was imposed on Estelline Spring, Texas to prevent surface discharge and subsequent natural salt pollution of the Red River. This paper describes the use of tritiated water as a tracer to determine the rate of subsurface leakage of the Spring, the size of the Spring cavern, and the location of that area where subsurface leakage returns to the surface. Other techniques using salt and organic dyes did not prove successful, due largely to insensitivity in detection and probable losses to adsorption and degradation. The volume of the known spring chimney, including that within the dike, amounts to about 389,800 cu ft. Knowing the amount of tracer added and the initial concentration of tracer after mixing, it was determined that a volume of 493,960 cu ft existed. From these data, it is concluded that a second chamber exists below that which was previously known; and its volume amounts to about 104,000 cu ft.

68-69:07B-019
A FAST-RESPONSE, FIELD TENSIOMETER SYSTEM,
Rice, R.
Agricultural Research Service, Phoenix, Arizona
Transactions of the American Society of Agricultural Engineers, Vol. 12, No. 1, p 48-50, 1969. 5 fig, 5 ref.

Descriptors: Soil water movement, Evapotranspiration, *Tensiometers, *Instrumentation, Pressure measuring instruments, *Soil water, Moisture, Tension.
Identifiers: Transducers, Adelanto loam.

The multiple tensiometer system connected to a number of tensiometers through a hydraulic scanning valve performed satisfactorily for 10 months under field conditions. When the nylon tubing from the porous ceramic was exposed to the atmosphere, considerable pressure fluctuations due to short-term temperature changes occurred. Shielding the nylon tubing with insulated foam-rubber tubing eliminated these fluctuations. Response time of the tensiometers in Adelanto loam was sufficiently fast to obtain a reading within 2 minutes. The multiple-tensiometer system permits rapid-response measurement of a number of tensiometers with only one transducer. The system should be of value wherever pressure-head records at a number of points in a dynamic soil-water system are desired.

68-69:07B-020
RADIOMETRIC METHODS OF MEASURING THE SOIL MOISTURE CONTENT,
Dimaksyan, A.M., and Glazkov, N.P.
State Hydrologic Institute (Trudy GGI).
Soviet Hydrology: Selected Papers, No. 4, p 333-351, 1969. 15 fig, 1 tab, 18 ref.
Translated from Trudy Gossudarstvennogo Gidrologicheskogo Instituta, No. 168, p 3-30, 1969.

Descriptors: *Instrumentation, *Soil moisture meters, Soil moisture, Nuclear meters, *Nuclear moisture meters, Moisture content, Moisture meters.
Identifiers: *Gamma-method, *Neutron method, *Cadmium-ratio, Surface moisture meter, Deep moisture meter.

A review is given of the currently available methods for making soil moisture determinations. The theory of thegamma-method of measuring soil moisture is given, along with reasons for its limited application. A detailed analysis of the neutron method for measuring soil moisture is given. The use of the cadmium ratio in the calibration of a neutron moisture meter and moisture measurement is discussed. Detail accounts of investigations associated with the development of surface and deep moisture meters using the cadmium ratio principles are given.

68-69:07B-021
SEISMIC REFRACTION AND ELECTRICAL RESISTIVITY: TOOLS IN GROUNDWATER EXPLORATION,
Sendlein, L. V. A.
Iowa State University, Ames, Dept of Earth Science
Transactions of the American Society of Agricultural Engineers, Vol. 11, No. 6 p 890-892, 1968. 4 fig, 7 ref.

Descriptors: Groundwater, Hydrogeology, Aquifer characteristics, Geology, Seismology, Geophysics, Geologic mapping, Boreholes, Logging, Borehole geophysics, Resistivity, Subsurface investigations, Aquifer.
Identifiers: Geophone, Gish-Roony method.

The coordinated use of electrical resistivity and seismic refraction method in a geologic investigation can produce a relatively inexpensive and accurate means of subsurface exploration. Seismic methods measured the time of energy arrival at each geophone. These times were plotted and the breaks in the slope of the plotted lines represented different energy paths. The plot gave two types of information: (1) the seismic velocity of each layer, and (2) the depth to refracting interfaces. Seismic velocity was correlated to rock type. Electric resistivity measurements measured changes in apparent resistivity which were plotted and compared to master curves to determine true resistivity and thickness. Bore hole methods were used, information based on soil samples, drillers well logs and electric well logging data. The coordinated use of geophysics and geology applied to groundwater problems helps provide maximum geologic information from minimum investment.

68-69:07B-022
SOIL MOISTURE ESTIMATION BY THE NEUTRON METHOD IN BRITAIN (A FURTHER REPORT),
Bell, J. P., and McCulloch, J. S. G.
Hydrological Research Unit, Wallingford, Berkshire, England.
Journal of Hydrology, Vol. 7, No. 4, p 415-433, 1969. 6 fig, 1 tab, 7 ref.

Descriptors: *Instrumentation, *Soil moisture, Nuclear meter, *Nuclear moisture meters, Moisture content, *Soil moisture meters, Calibration.
Identifiers: Britain.

Three different types of neutron scattering equipment for soil moisture measurement in routine use in Britain were compared. The purpose of the tests was to compare the interface effects and the resolution of the different gauges. Test profile No. 1 had a wet sand/air interface, while Test profile No. 2 had a dry soil/air interface; the sand and soil were chosen to have contrasting values of dry bulk density to show the effect of density on calibration. Test profile No. 3 was a natural, undisturbed soil profile. The magnitude of the effects of soil chemistry and bulk density on calibration curve are underestimated by many users. A single general calibration curve could be used, if the moisture differences are being measured over long periods and if an accuracy of ±0.02 M.V.F. is acceptable, and if in most circumstances chemical and density effects could be ignored.

68-69:07B-023
INSTRUMENTATION FOR MEASURING WATER POTENTIAL OF AN INTACT PLANT-SOIL SYSTEM,
Hoffman, G. J., and Splinter, W. E.
North Carolina State University, Raleigh.
Transactions of the American Society of Agricultural Engineers, Vol. 11, No. 1, p 38-40, 1968. 7 fig, 11 ref.

Descriptors: *Instrumentation, *Soil-water-plant relationships, Calibration, Hygrometry, Thermodynamics, Free energy.
Identifiers: *Thermocouple psychrometer, *Water potential.

Thermocouple psychrometer probes employing the Peltier effect and special instrumentation were developed for measuring the water potential of an intact plant-soil system for an extended period of time under precise temperature and relative humidity control. The thermocouple probe consisted of a measuring junction of 0.001-in. diameter chromel and constantan wires inserted in a Teflon rod. The equilibration or sample volume of each probe was 0.005 cu in. over a leaf or soil measuring area of 0.043 sq in. The probes were attached to intact leaves with epoxy cement or inserted into an auger hole in the soil. Various concentrations of salt solutions were used for calibrating the probes. A test chamber was constructed in which temperature could be controlled within 0.001 C by utilizing several intermediate control steps to permit accurate water-potential measurements. Absolute temperature was measured within 0.001 C using a calibrated resistance thermometer and a six-dial potentiometer.

SECTION XXIX

RESOURCES DATA - EVALUATION, PROCESSING AND PUBLICATION (Group 07C)

68-69:07C-001
COMPUTER METHODS FOR TRANSIENT ANALYSIS OF WATER-TABLE AQUIFERS,
Taylor, George S., and Luthin, James N.
California University, Davis.
Water Resources Research, Vol. 5, No. 1, p 144-152, February 1969. 4 fig, 11 ref.

Descriptors: *Drawdown, *Mathematical models, *Digital computers, Groundwater movement, Saturated flow, Unsaturated flow, Water level fluctuations, Theis equation, Thiems equation, Dupuit-Forchheimer theory.
Identifiers: Pumping tests, Aquifer tests, Drawdown analysis.

Computer methods for calculating drawdown in unconfined aquifers are discussed. Solutions for the saturated and unsaturated flow of water to wells may be obtained simultaneously. The method solves the basic flow equations with given boundary conditions, taking into account the properties of the unsaturated zone and the contribution of vertical flow. The basic equations are listed and expressed in cylindrical coordinates. The steps to be used in computer solution by numerical analysis are listed and discussed.

SECTION XXX

ENGINEERING WORKS - STRUCTURES (Group 08A)

68-69:08A-001
CARBONATE SCALE IN ROMAN AND MODERN CANALS IN THE JORDAN VALLEY,
Underhill, H. W.
Food and Agriculture Organization of the United Nations, Iraklion (Crete).
Journal of Hydrology, Vol. 7, No. 4, p 389-403, April 1969. 4 fig, 2 tab, 15 ref.

Descriptors: *Scaling, *Canals, *Calcium carbonate, Hardness (Water), Irrigation water, Spring waters, Arid lands, Irrigation canals.
Identifiers: *Jordan.

Problems of loss of capacity of canals and pipelines carrying waters heavily charged with carbonates are not new; examples are described from classical and modern times in the Jordan Valley. An outline of the chemistry of carbonates in ground water is followed by a discussion of the chemical analyses of two springs in west Jordan. Different indices of calcium carbonate saturation are examined; as none of these indicates the delayed properties of such waters, the addition of an'aerated saturation index' is proposed. The rate of scale formation in the modern Ain Feseyl canal is estimated from chemical analyses. The relation between scale precipitation in man-made works and its formation under natural conditions is noted, and a historical footnote on the probable origin of the scale-filled Roman canal at Ain Feseyl is included.

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SECTION XXXIII

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